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ST. LAWRENCE RIVER PROJECT

FINAL REPORT

1942

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LONG SAULT CANAL ANALYSIS OF DESIGN

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CORPS OF ENGINEERS, U.S. ARMY

U.S. ENGINEER OFFICE • MASSENA, NEW YORK.

APPENDIX III-16 (3)

ST. LAWRENCE RIVER

PROJECT

* * * * *

FINAL REPORT

1942

LONG SAULT CANAL

ANALYSIS OF DESIGN

CORPS OF ENGINEERS, U.S. ARMY

U.S. Engineer Office - Massena, New York

July , 1942

U. S. Army. Corps of Engineers

APPENDIX III-16(3)

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Appendix

PART ONE - Long Sault Canal, Analysis of Design.

PART TWO - Long Sault Canal, Estimate of Cost.

PART ONE

LONG SAULT CANAL

ANALYSIS OF DESIGN

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Report "Investigations at Beauharnois Canal"
by Dana D. Leslie

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ANALYSIS OF DESIGN FOR LONG SAULT CANAL
AND DIKES NOS. 1, 3, 5 and 6

SECTION I

INTRODUCTION

1-01. GENERAL. This design analysis presents the general basis of design based on information and data available at this date for the Long Sault Canal and Dikes 1, 3, 5 and 6, a part of the development of the International Rapids Section of the St. Lawrence River. Dikes 1, 3, 5 and 6 were studied as it was determined that these dikes can be economically constructed as suitable material can be obtained from canal excavation.

1-02. DESCRIPTION OF PROJECT.

(a) Location. The Long Sault Canal will extend from the St. Lawrence River at Richards Point, about three and one-half miles northwest of Massena, New York, to the same river at the mouth of the Grass River, about seven miles east of Massena.

(b) General Description of Canal.

(1) The overall length of the canal is approximately 10 miles and the bottom width generally 442 feet, with side slopes of 1 on 2 to 1 on 6. From Richards Point to Robinson Bay Lock site, the canal will be excavated to a bottom grade of elevation 210.5 M.S.L., and from Robinson Bay Lock site to Grass River Lock site, to elevation 173.0M.S.L. The above grades are designed to provide a depth of 27 feet at low water stages throughout the canal.

(2) Practically all the Long Sault Canal will be through pool areas with open water on both sides of the channel. Therefore this channel has been designed for a bed width of 450 feet for 25 feet depth, modified to 442 feet for 27 feet depth. These widths and depths originate in the Report of the Joint Board of Engineers, dated November 16, 1926. On account of the canal being routed through many areas of soft clay formation, the spoil banks have been placed at what is considered a minimum safe distance from the edge of the canal to eliminate the danger of slides, which would probably cause high maintenance charges. In the bank cuts in hard material the full width (442 feet) has been retained to provide sufficient material for building appurtenant dikes; thus dispensing with short bottlenecks in the canal which otherwise would occur, if the channel were reduced in width at these points. Considering prevailing winds and probably cross currents in the pool above the guard gate, full widths has been retained throughout this position of the channel.

(c) General Description of Dikes. The dikes along the canal will vary in height from 3 feet to 50 feet, will be compacted earth obtained from canal excavation, or from borrow and will be protected on the pool side with riprap. The crest of the dikes above Robinson Bay Lock site will be at elevation 254.5 M.S.L. and those below Robinson Bay Lock site will be at elevation 208.0 M.S.L.

(d) Purpose. The Long Sault Canal and dikes will serve to pass navigation around the Long Sault Dam and Power Houses which are to be built at the upper and lower end of Barnhart Island.

(e) Geology.

(1) The Long Sault Canal and dikes are located in a

region of low relief which has been greatly modified by glaciation and an invasion of the sea. The low hills in this area are composed almost entirely of glacial till, and the valleys have been filled with alluvial sediments laid down in the salt waters of the Champlain Sea.

(2) As the last glacier advanced over the region from the northeast, it scraped off the old residual soil and reworked it with fragments torn from the bedrock. When the ice became clogged with this material, the debris was scraped off the bottom of the ice and left plastered on the bedrock pavement while over it rode the great ice mass. Elongated lenticular masses of the material on the ice bottom were scraped off to form the low hills which at present give the region most of its present relief. These deposits are compact, variable, relatively impervious, unstratified till. The till contains material of all sizes from boulders to clay.

(3) Where the ice advance halted briefly fronting a valley transverse to its course, some material was washed off the ice front and became trapped in the valley bottom. These are deposits of small extent and consist of pervious sand and gravel beneath the compact till.

(4) Since much of the material transported by the ice was carried on or in the ice mass itself, when the glacier wasted away, these materials were deposited on the compact, bottom-ice till. Where melt-water was available for sorting, this material may be roughly stratified and washed to form deposits of relatively pervious sand and gravel. In other localities where ice dissipation was mainly evaporation, the material was merely dropped without sorting. This upper till blanket consists of loose to fairly compact, variable, cohesionless material varying in gradation from boulders to clay.

(5) The St. Lawrence Valley was depressed below sea level by the weight of the glacial ice so when the ice loan was relieved and the ice retreated northward far enough to uncover the mouth of the valley, the ocean spread inland and occupied the entire valley as far west as Brockville, Ontario. This salt water invasion is recorded in the alluvial sediments which have filled the valleys between the till hills, and is also evidenced by the beaches cut in these hills by the waves of the inland sea. These beaches are generally poorly devloped with wavebuilt terraces and offshore bars rarely exceeding 20 feet in depth. The material in these deposits is loose, stratified, pervious, cohesionless sand and gravel.

(6) In the valleys and lowland plains, deposits of marine clay occur. This clay was laid down in fairly deep water during the marine invasion and now forms deposits varying in depth from a few feet to over 60 feet. It is possible that the clay was deposited as a uniformly thick blanket over the entire submerged region but that as the hills emerged from the sea because of the uplift of the land, the clays were washed off the hills and redeposited in the valleys. Finally the water was left only in the valleys as narrow channels and wide shoals where from 5 to 20 feet of sand and brownish sandy clay, derived from inflowing rivers and wave action on the till hills, were deposited over the valley bottom deep water clay. The land continued to rise and the surface of the till and marine deposits are now approximately 225 feet above the Atlantic Ocean.

(7) The bedrock throughout the entire region is essentially flat-lying, early Paleozoic sedimentary rock which is believed to be a part of the Beekmantown or Chazy formations. The rock is mainly dolomite with minor strata of limestone, sandstone, and shale. Rock is deeply buried throughout the entire area in the vicinity of the canal. At the Grass River and Robinson Bay Locks the rock is buried to a depth of approximately 70 feet.

SECTION II

SELECTION OF CANAL ALIGNMENT

2-01. ALTERNATE PROPOSAL. Several alternate alignments have been studied to give best conditions for navigation as shown on Plate II-1.

(a) Original Location. The original location has several sharp angles which would be objectionable. In particular, a down bound steamer would encounter serious difficulties in making the sharp reverse bend at the head of Croil Island in windy weather. This location has two turns below the guard gate structure which would interfere with visibility and introduce some difficulty in navigation between the locks and the guard gate structure. Due to these objectionable features in this location alternate studies were made as follows:

(b) Alternate "A". This location eliminates two turns in the alignment below the guard gate structure thereby improving navigation and establishing complete visibility in the canal between the locks. The approach to the canal through Long Sault Island has also been improved by this change.

(c) Alternate "B". This location was studied to eliminate the reverse bend at the north end of Croil Island.

(d) Alternate "C". This location was studied to give a straight alignment from the channel south of Croil Island to Grass River.

(e) Alternate "D". This location was studied to locate the canal in low areas in order to reduce the excavation. This alignment introduces three changes in course over that of Alternate "C".

(f) Alternate "E". This location was studied to eliminate all objectionable changes in course, and reduce the excavation quantities below that of Alternate "C" and provide a good entrance to the canal.

(g) Alternate "F". This location was studied to reduce the excavation of alignment "E". In changing the alignment of location "E" a reverse bend was of necessity introduced into the course.

2-02. POSITION OF LOCKS AND GUARD GATE.

(a) The Robinson Bay Lock site was moved north due to the new canal alignment. This shift in location improved the excavation conditions by placing the entire lock structure in firm material.

(b) The Grass River Lock Site was moved approximately 1000 feet upstream and 200 feet south in order to secure better foundation conditions and greater safety and stability for the plug between the lock site and river during excavation for the lock and the lock construction.

(c) The Guard Gate site was moved to conform to the new alignment.

2-03. RELATIVE COSTS. The cost of excavation for the alternate alignments are as follows. These costs are based on the prices given in January, 1941.

CHANNEL ALIGNMENT STUDIES
Steens Island to Grass River
Canal 442' Wide, 1 on 3 Side Slopes. No overdepth

Designation	Excavation Cu.Yd.	No. of Angles	Max. Angle	Sum of Angles	Length in Miles	Total Cost of Excavation based on unit prices used in preliminary comparison estimate Jan.1941
Original Location	8,621,000	7	52°0'	188°-30'	13.7	$4,310,500.00
Alternate "A"	11,377,000	5	52°0'	150°-0'	13.4	5,688,500.00
Alternate "B"	13,997,000	3	47°30'	82°-0'	13.1	6,998,500.00
Alternate "C"	19,118,000	2	17°0'	20°-30'	12.6	9,559,000.00
Alternate "D"	16,844,000	5	27°0'	78°-0'	12.7	8,422,000.00
Alternate "E"	17,004,000	5	14°-30'	25°-0'	12.6	7,293,115.00
Alternate "F"	14,085,000	5	27°-0'	72°-30'	12.7	7,042,500.00

2-04. SELECTED ALIGNMENT. Having in mind the hazards to large steamers of the present and future while operating in narrow and constricted channels with uncertain currents combined with darkness, fog, snow, and high winds, every effort has been made to select a location which will minimize these hazards. Particular attention has been given to the provision of an upper entrance to the canal which a pilot can find with no great change in course or difficulty after being caught in a snow storm while down bound through the pool from the Point Rockway Canal, a distance of about 17 miles, involving at least 2 hours of uncertainty of position.

Due to the high insurance rates on ships and cargoes passing through narrow channels with many changes in course every effort has been made to eliminate danger of collision and stranding insofar as possible by keeping an alignment as direct as the topography will permit. Slight changes of direction have been introduced at Stations 320, 470, and 527 + 90, but since visibility at these points will be good, no great expense is justifiable for their elimination.

The route designated as Alternate "E" in this memorandum has been selected as that most satisfactory for the location of a ship canal having the importance of the Long Sault Canal.

The location of dikes necessary to maintain the pool level above the Long Sault Dam and the pool level between the two locks in the Canal has been considered in conjunction with the location of the ship canal. Many alternate locations have been considered and the present arrangement and location of these dikes is the simplest, cheapest and easiest of maintenance that these studies have produced.

SECTION III

INVESTIGATIONS OF OVERBURDEN AND FOUNDATIONS FOR CANAL AND DIKES NOS. 1, 3, 5 AND 6 AND OF EMBANKMENT MATERIALS

3-01. FIELD EXPLORATION FOR CANAL EXCAVATION AND DIKE FOUNDATIONS.

(a) General.

(1) Prior to October 1940, the Governments of Canada and of the United States and various private companies conducted investigations in the vicinity of the Long Sault Canal for the purpose of determining overburden conditions. This field exploration was chiefly of a preliminary nature and served in planning the general layout of the canal and dikes. It consisted of drilling holes through the overburden by wash boring and into bedrock at certain holes using a core bit. Detailed field logs and data for the exact location of most of these holes were not available for use in design.

(2) The exploration at the Long Sault Canal and dike sites since October 1940, conducted by the U. S. Engineer Department for the purpose of obtaining information for design, included drilling and sampling in overburden and rock, excavation and sampling of test pits and auger holes, probing in soft overburden, and the determination of bedrock elevations and general soil conditions by the seismic method. Extensive geological reconnaissance held an important part in the planning and integrating of the entire field exploration program. This program was carried out jointly with the investigation of general conditions and the surface topography of bedrock for the location of the Robinson Bay and Grass River Locks which affect the canal alignment. To present a complete picture of the overburden conditions for this analysis of design the location and extent of all exploration which is located within the area of the maps are shown on Plates III-1 to III-47. Coordinates for the location of all drill holes are given on Plates III-1 to III-4. The plans of exploration for the Long Sault Canal and Dikes Nos. 1, 3, 5 and 6 on Plates III-5 to III-14 also include exploration made specifically for the guard gate, Dike No. 2, Robinson Bay Lock, Dike No. 4, Grass River Lock, and Dikes Nos. 7 and 8, the design of which are not included in this analysis of design. The plates also include the location of exploration made for various initial alignments of the canal and dikes. However, plans of exploration on sheets MC-1-10/1 to 10/7 of the contract drawings for the Long Sault Canal and Dikes Nos. 1, 3, 5 and 6 show only that exploration within or adjacent to the contract limits which gives information considered pertinent to construction.

(3) The classification records for all exploration located on plates III-5 to III-14, except test pits in the series T-1 to T-1500, are shown in numerical order for the canal on Plates III-15 to III-38, and for the dikes on Plates III-39 to III-42. The records of exploration shown on sheets MC-1-10/8 to MC-1-10/27 of the contract drawings are limited to that exploration which is located on the contract drawing plans of exploration and are arranged according to location without regard to numerical order. Complete field logs and laboratory reports for the drill holes, test pits, auger borings and probings and the results of the seismic investigation are on file in the district office. All soil samples and rock cores are stored in the district soils laboratory.

(b) Drill Holes.

(1) Holes of three sizes were drilled in the vicinity of the canal and dike sites. Holes for the purpose of determining both overburden

and bedrock conditions were drilled with diamond core drilling equipment using 3½-inch casing in the overburden and a 2-1/8-inch bit to obtain cores of bedrock. Those drilled specifically for overburden investigation were drilled using 2½-inch, 3½-inch, or 6-inch casing. All holes whose numbers are D-1500 or higher were drilled with 2½-inch casing. When 2½-inch and 3½-inch casing were used, the overburden was dry sampled with sampling tubes 1½-inches and 2-inches in diameter, respectively. Soil samples were usually taken at 5-foot intervals or at changes in material, and wash boring between samples was permitted. These samples were stored in glass jars and were used for general classification, mechanical analysis tests, and water content determinations. The extent of the drilling using 2½-inch and 3½-inch casing is shown in the following tabulation:

Site	Total holes drilled 2½"	3½"	Overburden (ft.drilled) 2½"	3½"	Rock (feet drilled) 2½"	3½"
Canal(including locks and guard gate)	95	85	3918.4	6502.3	-	1877.8
Dike No. 1	4	-	163.1	-	-	-
Dike No. 3	4	11	221.0	572.6	-	20.4
Dike No. 5	-	-	-	-	-	-
Dike No. 6	-	1	-	46.5	-	20.0
Total	103	97	4302.5	7121.4	-	1918.2

The extent of drilling with 6-inch casing is described in the paragraph which follows. Coordinates for the location of all drill holes are given on Plates III-1 to III-4.

(2) Holes with 6-inch casing were drilled to obtain undisturbed samples of clay materials for testing and observation purposes. These holes were located to obtain representative samples from the various clay deposits after a study of samples from other exploration. Hole D-1156 was located in the Grass River Lock area, D-1160 in the canal below the Robinson Bay Lock, D-1168, D-1243 and D-1279 within the area of Dike No. 3, and D-1399 within the area of Dike No. 1. At most of the locations samples in insufficient number were obtained from one hole, and therefore additional holes were drilled. These additional holes, which are designated by the suffix letters "A" and "B" attached to the original drill hole number, were drilled within 20 feet of the original hole, and samples obtained at similar depths were considered identical. Although D-1156 is located within the Grass River Lock area the material at that hole is considered to be typical for part of the canal.

(3) Attempts were made initially at D-1156 and D-1156 A to obtain samples 4-7/8 inches in diameter with the M.I.T. undisturbed sampling spoon. Although great care was taken in pressing and retracting the spoon considerable difficulty was encountered in obtaining samples. In 66 attempts only 37 samples were recovered, and some of these were not full length samples. Because of this difficulty in sampling, a spoon specially constructed by Sprague & Henwood was used at all subsequent 6-inch holes except at D-1160 where the M.I.T. type of spoon was used. The specially constructed spoon, which has a cutting shoe 4-3/8 inches inside diameter, is equipped with two steel liners 0.12 inches thick, 12 inches long, and 4-3/4 inches inside diameter. Recessed flaps are provided within the cutting shoe and are closed by means of a wire snare in order to hold the samples in the spoon. Connections are provided to apply suction at the top of the sampling spoon and compressed air at the bottom, or open end, to aid in retaining the samples against the

suction which occurs when the spoon is retracted from the bottom of the hole. Photographs of this apparatus are shown on Plates III-48 to III-52. The recovery of samples with this spoon was much more satisfactory although a few samples were lost. Some samples were lost at depths between 26 feet and 30 feet and between 45 feet and 50 feet at D-1160A and near the bottom of D-1243 where material was either too soft to be retained by the flaps or may have been unaccountably disturbed.

(4) In sampling as steady a pressure as possible was used to press the spoon into the soft soils. Pressures estimated at from 1,000 to 4,500 pounds were exerted on the sampler using the weighted drill platform as a fulcrum and a long bar as a pry. When necessary the bottom of the hole was carefully cleaned with a spoon having a flap valve before samples were taken. The material was sufficiently soft so that it was usually necessary to clamp the casing to prevent it from sinking under its own weight. Familiarity and actual contact with the drilling and sampling operations in the field were valuable in understanding the difficulties encountered and in gaining familiarity with the materials. Field and laboratory logs are on file at the district office giving a detailed reocrd of the sampling operations at each hole. A total of 552 feet was drilled with 6-inch casing at the canal site and Dikes Nos. 1 and 3, and 217 samples were taken for undisturbed tests. All undisturbed samples were sealed in paraffin and confined in metal cylinders immediately after sampling.

(c) Test Pits. - A total of 111 shallow test pits was excavated and sampled at the canal and at the sites for Dikes Nos. 1, 3, 5, and 6. Test pits were used for shallow exploration in certain dike foundation areas and in prespective borrow areas and also for the purpose of locating boundaries between clay overburden and till. In general, test pits were excavated to a depth of approximately 6 feet and werever possible were extended by auger bori g Bag or jar samples were taken in each general strata of material encountered. One sheeted test pit, T-1000p, located 10 feet from D-1154 near Tracy's Landing on a preliminary alignment for the canal, was excavated to a depth of 15 feet, and 11 undisturbed samples of clay were taken. Clay encountered in drill hole D-1154 appeared to be so soft that the deep pit was excavated to permit visual inspection of the clay in place and to obtain undisturbed samples for shear and consolidation tests.

(d) Auger Holes. - A total of 501 auger holes was completed to aid in the exploration of overburden conditions along the canal alignments and in the vicinities of the dikes. Auger borings excavated with a 5 or 6-inch hand auger were used wherever overburden conditions permitted and were excavated as deep as possible after which the holes were generally extended by probing. All auger holes designated by numbers greater than 1,500 are located along the canal alignment. Jar samples were taken at changes in material in all auger borings.

(e) Probings. - Two types of probing were used to determine overburden conditions along the canal alignments and at the dike sites. Hand probings using 3/4-inch rods and a 14-pound sledge hammer were used to extend auger borings and in areas where augering was impossible. The notation "P" designates holes which were hand probed. In certian soft foundation areas on Dike No. 1 and Dike No. 3 a Highmark Probing Machine was used to determine the depth to firm material, and these holes are designated "PH". The Highmark Machine drove a 1¼-inch probing pipe with a removable, closed, pointed end which could be retracted without pulling the casing when samples were desired. To obtain samples in clayey materials, a sampler consisting of an open and 3/8-inch inside diameter pipe was forced into the soil below the probing pipe. In sandy materials,a sampler consisting of a closed and 3/8-

inch inside diameter pipe with a slot 2 inches from the bottom was used. The samples thus obtained were either soils washed through the slot or scraped through the slot as the sampler was moved up and down a number of times. The probing pipe was driven with a hammer weighing 163 pounds, dropping approximately 15 inches at an average rate of 50 blows per minute. A field log was prepared for each probe hole, and rates of penetration, as well as the description of samples obtained, were recorded. A total of 85 holes was probed with this machine for a total footage of 3431 feet. Machine probing results are shown on Plates III-43 to III-47.

(f) Seismic Investigations. - Preliminary investigations for the determination of bedrock elevations and existing soil conditions in the vicinity of the canal were conducted using the seismic method. The method employed was developed by E. R. Shepard, Senior Physicist. Office of the Chief of Engineers. A report describing the entire seismic investigation conducted at the St. Lawrence River Project is on file at the district office. Only lines considered to have a better than fair degree of accuracy are shown on the plans of exploration (Plates III-8 to III-14). Care was taken to avoid using the results from certain lines where difficulties such as deep ground frost interfered with the accuracy. A total of 24 seismic lines were considered reliable in the vicinity of the canal and dike sites.

3-02. FIELD EXPLORATION FOR DIKE EMBANKMENT MATERIALS.

(a) Embankment Fill. - At the adopted dike sites material from canal excavation will be used for all earth fill sections of dike embankments. The exploration along the canal therefore served as borrow exploration for embankment materials. It is expected that sufficient selected material of suitable characteristics will be economically available from the required canal excavation to make additional exploration for earth fill unnecessary. In case additional earth fill is required, limited preliminary exploration has been carried out in a silty, gravelly sand deposit to the south of Dike No. 3.

(b) Sand and Gravel Filter and Backing. - A survey of nearby sources of suitable sand and gravel to be used in filter blankets and backing on the dikes was undertaken jointly with the investigation for backfill behind lock walls and for concrete aggregates. It is believed that all deposits within a radius of 15 miles of the sites have been located. The most feasible deposits were sampled and tested to determine the gradation of the material. Certain larger deposits at a greater distance but readily accessible by railroad or barge were investigated, as well. A complete report of these investigations is on file in the district office.

(c) Riprap. - No exploration has been made for riprap since sufficient quantities will be available from hand-picked stones, cobbles, and boulders from earth embankment materials and canal excavation.

3-03. ROUTINE LABORATORY TESTS.

(a) General. - The purpose of the soil testing program was to determine from samples and data obtained during field exploration the characteristics of overburden materials throughout the canal site and of foundation and embankment materials at the dikes for the design and construction of stable excavation and embankment slopes. Routine tests were made to aid in the determination of the general characteristics of materials, and special tests were made to establish values specifically for design purposes. Routine tests which were made in the district soils laboratory at Massena included

classification, moisture content, specific gravity, and density tests. This program was supplemented by a testing program on undisturbed clay samples at the Binghamton District Soils Laboratory at Ithaca, New York. The testing at Ithaca consisted of Atterberg limits, consolidation, shearing strength tests, and the above routine tests. The results and data of all testing including a report prepared by the Binghamton District are on file in the district office.

(b) Classification. - All samples from drill holes, test pits and auger borings were classified using the M.I.T. scale of soil classification, and the results are recorded in laboratory reports for each hole and on the records of exploration (Plates III-15 to III-42). The grain size distributions of a sufficient number of typical samples were determined by the usual sieve and hydrometer methods to serve as a guide in the classification of all samples. General geological descriptions of the overburden at each hole were also prepared after studying the laboratory classifications and the field log descriptions and are recorded in each laboratory report. The bedrock was classified by a geologist after examining the rock cores and field logs.

(c) Moisture Content. - Water contents were determined as a percentage of dry weight for a large proportion of all samples of overburden at drill holes and for selected samples from test pits. Determinations for water content were made from jar samples of clay and till as they were received from the field. Similar determinations were made in connection with the testing program on undisturbed samples of clay overburden. Original water contents were taken on all samples used in triaxial shear tests, and in tests of the consolidated quick shear type some determinations were made both before preconsolidation and after completion of the test. A tabulation of results from hole D-1759 where the overburden is typical for glacial till in the canal area is shown on Plate III-56. Plots of water content versus depth at holes D-1156, D-1160 and D-1243 which are in soft clay deposits are shown on Plates III-53 to III-55. The results of the water content determinations made during the shear testing program are shown on Plates III-62 to III-65.

(d) Specific Gravity. - Specific gravity determinations were made for the solid particles of several representative soil samples of foundation and embankment materials using a calibrated volumetric flask. A tabulation of the results is presented on Plate III-57. An average value for clay particles is considered to be 2.73, and for the run of till 2.74.

(e) Density. - Natural density determinations were run on several of the undisturbed samples taken from clay areas along the canal and from dike foundations. An average saturated weight of 103 pounds per cubic foot is considered typical for the soft gray clay in its natural state which corresponds to a void ratio of 1.65. The brown sandy clay has a somewhat greater density. A tabulation of results from the determinations made is shown on Plate III-56. From the results of a few tests and the examination of samples the unit wet weight of the till in place is estimated to be from 140 to 150 pounds per cubic foot.

(f) Atterberg Limits. - Determinations for the liquid limit and plastic limit were made on several samples of clay from holes D-1156 and D-1160 in the canal and from D-1243 and D-1279 at Dike No. 3. These determinations, expressed as a percent water content of dry weight, are used as a basis for classification and give some indication of the relative shearing strengths of the various clay deposits. The results of these tests are included on Plate III-58.

3-04. DETERMINATION OF SHEARING STRENGTH AND CONSOLIDATION CHARACTERISTICS OF SOILS.

(a) General.

(1) Two general classifications of overburden materials were indicated by preliminary exploration in the vicinity of the Long Sault Canal. The first of these general classifications includes the glacial tills, the water-laid sands, and the partially water laid sands which in this analysis are considered firm materials. The firm materials do not present any critical problem in design. Assumptions as to their shearing strength have been made for use in design based upon experience with similar materials. No actual shearing strength or consolidation tests have been performed on these materials. The second of the general classifications includes the softer materials consisting of the soft gray marine clays and the brown sandy clays. Areas of soft materials along the adopted canal and dike alignments produce a major problem in the design of canal excavation and embankment slopes. The evaluation of the natural shearing strength of the clays and of their consolidation characteristics was required for design. The brown sandy clay which overlies the soft gray marine clay to depths varying from 5 to 20 feet has a relatively higher shearing strength so that the critical element in the problem arises from the low shearing strength of the marine clay.

(2) Undisturbed samples from 6-inch drill holes located to obtain typical samples from critical areas were forwarded to Ithaca, New York, for testing at the Binghamton District Soils Laboratory. These included samples from two locations in the Long Sault Canal and from two areas at Dike No. 3 as stated in paragraph 3-01 (b) (2). Tests on samples from D-1399 at Dike No. 1 are not completed, and the results are not included in this analysis of design. The results will be placed on file in the district office when available. Other clay areas exist within the canal limits as on Long Sault Island and near Richard's Landing, but the undisturbed sampling and testing program as completed was laid out to give as typical and general coverage as possible within its limited scope. Both direct shear tests and triaxial tests were conducted to investigate strength values for design. Consolidation tests were run to furnish data for the computation of settlements for dike foundations, to study the degree of consolidation in the natural deposits and to aid in the analysis of data from shear tests. Tests were made to determine the sodium chloride content of the pore water in the clays.

(3) Although D-1156 was drilled to explore for the Grass River Lock which is not a part of this analysis of design, samples from this hole have been included in the testing program described herein. Not only are samples from this hole considered representative of the clays in part of the canal, but tests on these samples were made in conjunction with tests on other undisturbed samples to develop the testing procedure and to determine the general characteristics and variations of the clay deposits.

(b) Direct Shear Tests.

(1) Direct shear tests were a part of the preliminary investigation of the strength of clays and were made to compare the results from this method of shear testing with the results from the triaxial compression type of test. Direct shear tests were made using a constant rate of strain device similar to that described by Dr. Glennon Gilboy in Engineering News Record, May 1936, for which the size of sample is 3½ inches square by 3/4 inches thick. The shear box of the device was equipped with metal teeth separated by porous stones which premitted drainage at the faces, and all tests were made with the sample submerged to eliminate "apparent cohesion" or shearing strength caused by capillary pressures. Tests were run on samples from selected depths at drill holes D-1156 in the Grass River Lock section of the canal and D-1160 near the Robinson Bay Lock. Considerable consolidation was

observed to take place during the actual shearing of samples.

(2) The results of three series of direct shear tests on undisturbed samples of the gray marine clay are presented as plots of shearing stress versus normal stress on Plates III-59 and III-60. One series of tests (Quick Shear) was made by applying the normal load to the sample and shearing to failure without allowing consolidation under each normal load before the shearing strain was applied. A second series (Consolidated Quick Shear) was made allowing complete consolidation under each normal load before shearing to failure. Both of these series were made at a constant rate of strain of 0.05 inches per minute, failure occurring in from 12 to 20 minutes. The third series of tests (Consolidated Slow Shear) was made at a very slow rate of strain after allowing complete consolidation under each normal load , the objective being to apply shearing strain to the specimen at such a slow rate that pressure in the pore water would be hydrostatic at all times. In these tests the maximum shearing strength was reached in from 3 to 6 hours. Further direct shear tests on undisturbed samples were omitted after a comparative study of the procedures and results of these tests with those of the triaxial method.

(3) To investigate in the laboratory the behavior of the soft gray marine clay when seriously disturbed, a few direct shear tests were run on samples of the clay from drill hole D-1156 remolded at their natural water content. The shearing stress produced during quick tests was considerably lower than that produced in similar tests on undisturbed samples.

(c) Triaxial Shear Tests. -

(1) Triaxial shear tests, sometimes referred to as cylindrical compression tests, were made on undisturbed samples from all 6-inch drill holes except D-1168. The triaxial tests were made on a constant strain type of universal testing machine to which had been added equipment for applying a lateral pressure to the test specimens. Samples were prepared using a wire saw and a specially designed sample trimmer to finish them to size. Two sizes of samples were used, 4½ inches in diameter by 9 inches long and 2.8 inches in diameter by 5.6 inches long. Shear tests of three general types designated as "quick shear" tests, "quick shear tests at a slow rate of strain," and "consolidated-quick shear" tests are included in the five series described below. A discussion and conclusions on the shearing strength of the clays appear ir paragraph 3-04(e).

(2) The first series of triaxial shear tests consisted of 19 tests of the "quick shear" type made on 4 samples of brown, sandy clay from drill hole D-1156 and 15 samples of soft gray marine clay from holes D-1156, D-1160, and D-1160 A. This series was made on 4½-inch diameter samples by applying lateral pressure and then shearing to failure without allowing consolidation. Observations of the amount of pore water expelled through the porous drainage plates at the two ends of the sample indicated that very little change in volume or void ratio took place during application of the shearing strain. Tests were run using constant lateral pressures of 6, 15, 30, and 60 pounds per square inch. The rate of strain was 0.05 inches per minute, and failure occurred in approximately 20 to 30 minutes. A typical stress-strain curve for a test on gray clay is shown on Plate III-61. The test data, water contents, and Mohr circle diagrams for this series of tests are shown on Plates III-62 to 65 III-68 and III-69.

(3) A second series of tests on five 4½-inch diameter samples was made after allowing complete preconsolidation under a constant lateral pressure before shearing the specimen to failure. These tests are called "consolidated quick shear" tests. The five samples selected represented the range with depth at drill hole D-1156 B. Preconsolidation was carried out in

the pressure chamber of the triaxial testing device after the sample and the machine had been made ready for testing. Samples were allowed to consolidate for about four days under lateral pressures equal to the calculated submerged weight of the natural overburden on each sample. The axial load was then applied so that maximum stress conditions were reached within approximately 10 minutes. The test data, moisture contents and Mohr circles representing the results of these tests are shown on Plates III-62 to 66.

(4) A third series consisting of consolidated-quick shear tests was made on 2.8-inch diameter specimens of gray clay. The purpose of this series was to obtain strength data from which the shearing strength could be determined for the density and effective stress existing in nature. To obrain a range of values as stated in paragraph 3-04 (e), specimens were preconsolidated in general to pressures corresponding to saturated and submerged overburden loads. Consolidating pressures equal to the calculated value of these two assumed limiting pressures were applied to the two 2.8-inch diameter specimens prepared from each of several full length undisturbed cylinders selected to cover the range with depth at holes D-1156 B and D-1160 B. Individual preconsolidation was carried out in a group of special devices which were constructed for the purpose. Each specimen was wrapped axially in saturated blotting paper after porous stones had been placed at the ends. A rubber sleeve was then slipped over the specimen and bound top and bottom to metal caps which covered the open ends except for a vent to the outside at the top used to drain the sample during consolidation. With the sample held to the cover by a vacuum applied temporarily at the vent, the sample was then introduced into the cylindrical pressure chamber of the device and the air-tight cover was bolted in place. Air pressure held constant at the desired preconsolidation pressure by means of an automatic regulator valve was then applied to the chamber. After the preconsolidation pressure had been held on the sample until the water level in the burette tube attached to the vent from the sample had become stationary the sample was transferred directly to the triaxial testing device where a lateral pressure equal to that used in preconsolidation was reestablished. During the transfer the blotting paper was removed from around the sample. After allowing approximately 15 minutes for readjustment under this lateral pressure a quick shear test was run so that the maximum stress was reached within approximately 5 minutes. Similar tests were made on samples of gray clay from holes D-1243 and D-1279 using preconsolidation pressures arbitrarily assigned to cover the estimated material overburden range. The rate of strain for this series was 0.10 inches per minute. Mohr circle diagrams for these tests appear on Plates III-66, 67, 70 and 71.

(5) A fourth series consisting of tests of the quick shear type on 2.8 inch diameter samples was made under lateral pressures equivalent to the estimated intergranular pressure acting on the sample in nature. The samples were sheared to failure at a constant rate of strain of 0.10 inches per minute. This series included tests on samples from D-1156 B, D-1160 B, D-1243, and D-1279, and the Mohr circles are shown on Plates III-68 to 71.

(6) A final series of quick shear tests on 2.8-inch diameter samples was made at a very slow rate of strain. Tests of this series were made on five samples from hole D- 1156 B to determine whether indications exist of a reduction in the shearing strength of the clay if stresses are applied more slowly. Evidence of such a reduction in strength was found in tests on certain clays at the Panama Canal. The rate of strain was reduced to 0.003 inches per minute, and the series included tests run under lateral pressures of 6, 15, and 30 pounds per square inch and one unconfined compression test. To prevent a volume change in the samples during these tests

the porous drainage stones normally used were replaced by brass discs. The data and Mohr circles for the series of quick shear tests at a slow rate of strain appear on Plate III-68.

(7) The unconfined compression tests for which the Mohr circles are shown on Plates III-68 to 71 with results from quick shear tests were made using the same triaxial machine and testing procedure used for the other tests, the only difference being that no lateral pressure was applied. In some of these tests a rubber sleeve was placed around the sample to duplicate the restraint offered in the regular triaxial tests and also to prevent evaporation.

(d) Consolidation and Sodium Chloride Tests. -

(1) Consolidation tests, using a device for which the size of specimen is 4½-inches in diameter and 1¼-inches high, were made on undisturbed samples of clay from the canal and dike sites. Samples were chosen to give an indication of the variation of consolidation characteristics with depth. Tests on undisturbed samples were made to obtain pressure-void ratio curves from which the preconsolidation loads might be estimated. This information was expected to be of use in planning the shear testing program and in interpreting the shearing strength data obtained. Tests on undisturbed clay samples from areas of soft dike foundations were made to provide data for computing the settlement of dike foundations. The consolidation tests completed included runs on undisturbed samples from all 6-inch drill holes. Tests were run on two remolded samples from drill hole D-1156 B. Pressure-void ratio curves for the tests on undisturbed samples referred to above are shown on Plates III-72 to 75 and typical time-consolidation curves are shown on Plates III-76 to 80. Consolidation tests on firm materials were not conducted because general experience with similar materials was considered sufficient to permit the assumption of average values for design.

(2) Sodium chloride tests were made to determine the salt content in the clay pore water by precipitating the chloride as silver chloride. The tests showed that the pore water is "fresh."

(e) Discussion and Conclusions on Shearing Strength.

(1) At the present time there is no general agreement of opinion concerning the best method for determining the shearing strength of clays. For this reason a review and discussion of progress and preliminary results from the shear testing program were fully considered at several conferences between the supervising engineering personnal of the St. Lawrence River District Office and representatives from the Office of the Chief of Engineers, the official consultants, and the engineers in charge of the test work at the Ithaca Soils Laboratory. Memoranda covering these conferences and certain official correspondence relating to the development of the testing program on undisturbed samples are on file in the district office with the report prepared by the Ithaca Laboratory. The shear test series discussed below are described in paragraphs 3-04 (b) and 3-04 (c).

(2) The results of the direct shear tests and initial triaxial tests made on samples from D-1156 and D-1160 were compared. (Plates III-59, 60, 68 and 69.) The "no-load" shearing strength for both types of tests was approximately 100 to 400 pounds per square foot. A large apparent angle of friction was obtained in the direct tests which indicated that a large amount of consolidation took place during the tests. The shearing strength indicated by the confined quick triaxial tests was nearly constant for all loads and was approximately 600 to 700 pounds per sq. foot. It was concluded from the results of the direct shear tests on remolded samples that the shearing strength of the soft gray clay when remolded is very small. This conclusion is also justified by the fact that the liquid limit of the soft grey clay is 47 per-

cent compared with a natural water content of approximately 57 percent.

(3) After a review of the conditions which would affect the design of cuts in clay and dikes on clay and after a study of the results from the direct shear tests and from the first series of triaxial quick shear tests mentioned above, it was decided to conduct triaxial consolidated-quick shear tests (see paragraphs 3-04 (c) (3) and (4) to attempt to determine the shearing strength of the clays at their present effective stress in nature. According to geological history, the effective stress should be approximately equal to the present overburden load. At no time since the clay deposits were formed has there been any superimposed loads. The deposits have been formed for at least 10,000 years and therefore should be fully consolidated under the present overburden load. The results of the sodium chloride tests described in paragraph 3-04 (d) indicates that the original salt water which filled the voids has been replaced by fresh water. However, according to the basic consolidation theory of clay deposits, there should be a gradual increase in density with depth if the deposits are consolidated under the present overburden weight. At most of the holes this did not appear to be true in the grey clay deposits as indicated by the moisture contents, uniform resistance during sampling operations and the occurrence of relatively slightly softer clays in strata at various depths. Deposits with similar characteristics have been noted by various engineers. Dr. Terzaghi discusses the effect of slow sedimentation in relation to consolidation which produces these characteristics in a paper "Undisturbed Clay Samples and Undisturbed Clays" published in the Journal of the Boston Society of Civil Engineers, July 1941.

(4) In order to assure bracketing the stress conditions existing in nature, the triaxial consolidated quick tests were made on specimens consolidated under loads equivalent to the submerged and saturated weight of the overburden. The unit submerged and saturated weights were assumed to be 45± and 110± pounds per cubic foot respectively. The water contents of the specimens prior and after testing were determined in order to compute the change in void ratio. To determine the consolidation characteristics and the preconsolidated loads, consolidation tests were made on numerous specimens. It was hoped that the effective stress in nature would be indicated by the results of the consolidation tests and that the shearing strength for this stress could be determined from the results of the shear tests. This interpolation might be made if the densities of the specimens during the test corresponded to the densities in nature. Extensive tests were made on samples from D-1156 and D-1160 were used for most of the studies.

(5) The data, moisture contents and Mohr circles are shown on Plates III-53 to 58 and 62 to 80. A study of all data indicated the following:

a. The moisture content in the soft grey clay deposit is nearly uniform with depth except near boundaries.

b. The shearing strength of the soft grey clay during test is only dependent upon the consolidation load during test and independent of depth from which the samples were taken. That is, if two samples were taken from different depths the results of consolidated quick tests would be the same if the same consolidation loads were used.

c. Consolidation test loads equivalent to the submerged weight of the overburden changes the void ratio approximately 0.1 and the water content less than 3% (dry weight).

d. Consolidation test loads equivalent to the saturated weight of the overburden changes the void ratio and water content appreciably.

e. No hydrostatic excess exists in the clay deposits.

(6) After a complete study of the results of all quick tests, consolidation-quick tests, consolidation tests, water contents, drilling and sampling operations, and visual inspection of various samples it was concluded

by the majority of the engineers involved in the study that the design value shearing strength should be chosen from the results of quick shear tests. One dissenting member recommended that the results of consolidation-quick shear tests be used assuming that the effective load at any point is equal to the submerged weight of the overlying overburden.

(7) The results of the original quick tests were studies and it was noted that in most cases, the results of unconfined tests were smaller than the results obtained by applying a lateral load. It was concluded, after watching several unconfined tests, that the results are not representative due to the formation of initial cracks. It was finally concluded that the average of all quick tests made using a lateral pressure should be used for design purposes. More quick tests at various lateral pressures were made to complete the data furnished in part by the initial quick tests. On the basis of conclusion, the shearing strength of the soft grey clay at each location was assumed constant and has values as follows:

Drill Hole	Site	Shearing strength Lbs. per sq. ft.
D-1156	Grass River Lock	680
D-1160	Long Sault Canal	600
D-1243	Long Sault Canal Dike No. 3	540
D-1279	Long Sault Canal Dike No. 3	800

(8) The firm sandy clay at hole D-1156 has a shearing strength greater than that of the underlying soft grey clay as shown on Plate III-68. From special tests it was concluded that the results of quick shear tests run at a very slow rate are practically the same as those obtained when the tests are run at the usual rate.

3-05. SPECIAL INVESTIGATIONS

(a) General. - To aid in the design of canal slopes and dikes for Long Sault Canal, certain projects having similar problems and soil conditions have been investigated. All pertinent data which may be of some value has been collected and is on file in the district office.

(b) Beauharnois Power Development.

(1) An investigation was made of the methods and experience during construction at the Beauharnois Canal and hydro-electric development on the St. Lawrence River between Lake St. Francis and Lake St. Louis, approximately 22 miles west of Montreal. Starting in 1929 a canal was constructed approximately 15 miles long with 30 miles of dikes many of which were constructed over areas of soft clay. A complete report of these investigations is presented in Appendix A of this analysis of design.

(2) Field exploration at the Beauharnois Power Development undertaken by the U. S. Engineer Department in 1941 included 10 auger borings designated AB1 to AB10 and two 6-inch drill holes, D-1293 and D-1294, made for the purpose of taking undisturbed samples for observation and laboratory testing. These tests were desirable to provide data for check calculations on the failures which occurred at Beauharnois and for comparison with test data for clays at the Long Sault Canal. A complete record of this exploration and testing form an addenda to Appendix A of this analysis of design.

(3) From the investigations it is concluded that, in general, the clays at Beauharnois with an average water content above 80 percent have less strength than the clays found at the Long Sault Canal and dike sites.

Triaxial quick shear tests on undisturbed samples of the soft clay from D-1293 and D-1294 at the Beauharnois development indicated a natural strength of approximately 300 pounds per sq. ft. independent of depth. In some areas canal dikes built upon the clay using slopes of 1 on 3 failed when construction had reached a height of approximately 24 feet. One railroad embankment with slopes of 1 on 1.5 slumped after being built to heights varying from 20 to 25 feet. Using the circular arc method of analysis and assuming various unit weights of materials and depths of soft foundation check analysis were made for these conditions of failure. Strength values from 350 to 450 pounds per sq. ft. were indicated by these studies for the clay foundations. These values are somewhat higher than the value obtain from the triaxial quick shear tests, but no allowance had been made in the analysis for the surface crust of stiff sandy clay or for variations in the construction procedure. The tendency of the surface crust to increase the stability of the dikes was noted by engineers during construction. Experience at Beauharhois indicated that dikes could be built to heights approximately the same as those referred to above without failure wherever the surface crust of sandy clay had a minimum depth of 5 feet.

(c) Massena Power Canal. - The power canal operated by the Aluminum Company of America at Massena, New York, has been studied and all available data on the construction of the canal has been collected and put on file in the district office. This canal which is located in the same vicinity as the Long Sault Canal was originally excavated over thirty years ago and has since been deepened to approximately forty feet. Because similar soil conditions exist at both sites field reconnaissance and an inspection of the behavior of excavation slopes was made at the power canal. During the summer of 1941 cross sections were taken by personnel of the district office at three locations along the canal. Till slopes with a maximum height of 100 feet, 40 feet of which is submerged, have been standing on slopes of 1 on 1.75 without signs of major slides. Some erosion and sloughing has taken place which has required maintenance. Slopes in some clay areas have been continually sliding, but at present clay slopes are approximately 1 on 3 where they are completely submerged. Constant maintenance has been required in clay areas, and in one such area successive slides have occurred so that the surface breaks 200 feet back from the normal edge of the canal and at that point stands only 10 feet above the water level in the canal.

3-06. PROPOSED FUTURE INVESTIGATIONS.

(a) General. - Various future investigations are proposed at the Long Sault Canal and dike sites to be conducted prior to or during actual construction. The outline of these investigations is presented below.

(b) Field Exploration. - Additional drilling for undisturbed samples should be undertaken in areas of deep clay foundations along Dikes Nos. 1 and 3. More extensive knowledge concerning the natural strength of clays in these areas may permit the design of more economical sections for dike embankments over critical areas. Additional exploration is not considered necessary within the limits of canal excavation covered by this analysis of design. Additional exploration to obtain undisturbed samples of clay at the Grass River Lock site is being recommended in the separate analysis of design for that structure. Information which may be obtained from additional investigations in that area may be considered applicable to the design of canal excavation slopes in certain areas at the lower end of the canal.

(c) Test Trenches in Clay. - Recommendations are made to construct test trenches in the clay in the vicinity of the Long Sault Canal prior to construction to determine the shearing strength of the clay and to make a

comparison of the results obtained from the test trenches with these obtained by laboratory tests. To accomplish this comparison sufficient undisturbed samples must be taken at the site chosen for the test trenches using the same equipment and methods used for the undisturbed sampling already completed. The laboratory testing program on these samples should also parallel the work previously done to make the comparison valid. A suggested location for the test trenches is in the vicinity of drill hole D-1168 in the Dike No. 3 area. At this location stripping to a depth of not more than 5 or 6 feet would be required to expose the apparently uniform soft gray clay. The proposed trenches should be entirely in uniform soft gray clay, and should be excavated with great care to avoid jarring and to obtain a uniform depth. The trenches must be narrow to control the desired ultimate failure at the toe and must be of sufficient length to eliminate arching action. Trenches 150 feet long and as wide as a drag line bucket in areas stripped to the gray clay over a width 50 feet each side of the centerline are believed to be satisfactory. The area should be kept dry, and it is suggested that excavation of one trench be continuous until failure and that excavation of the second trench procede at a rate of 2 feet per day after the depth of the trench has reached 15 feet. At this location, the failure in such tests can be predicted to occur when the depth of the trench reaches approximately 22 feet.

(d) Test Embankment on Clay. - The construction of a test embankment on clay is desirable to obtain a field check on the design method used for the dike analysis. Such a test embankment should be constructed where top soil and roots have been removed to get uniform strength in an area of known shearing strength. The test embankment would be built to failure, and check analysis subsequently made. This type of test would be of greatest value after the shearing strength of the dike foundation had been investigated by a test trench as outlined above. Otherwise, a complete program of undisturbed sampling and laboratory testing should be undertaken for the foundation materials at the site selected for the test embankment.

(e) Settlement Tests. - The installation of settlement plates is recommended on clay foundations at the dikes. Such plates will be used for the purpose of determining fill quantities and will furnish valuable data to check computations of settlement at the various dikes. Maximum final settlements of approximately 4 to 6 feet are expected to occur.

(f) Hydrostatic Pressure Tests. - Field tests are recommended to study the hydrostatic pore water pressure in clay areas at dike foundations and canal cuts. The test should be made for the purpose of analysing present and future stress conditions in these areas and to provide information which would give indications of impending failures during construction. A complete change of pore water appears to have taken place since the original deposition of the marine clays, and from observation it would appear that no hydrostatic excess pressures exist within these materials at the present time, notwithstanding that density shows no appreciable increase with depth. A careful check of the hydrostatic pressures before, during, and after construction is considered desireable.

(g) Laboratory Testing. - The testing program on undisturbed samples from drill hole D-1399 at Dike No. 1 is to be completed. Arrangements have been made with the Ithaca Soils Laboratory to conduct triaxial shear tests, consolidation tests, and certain routine tests on samples from the hole. Similar tests should be undertaken on samples from any exploration where it is considered advisable to do undisturbed sampling at dike sites in the future or at the test trenches and test embankment discussed in paragraphs 3-06 (c) and (d). Sufficient routine laboratory tests should be made to allow proper classification of material encountered at any future exploration. Tests

should be made during construction to determine the relation between water content and unit weight to be obtained when compacting the selected materials in dike embankment cores.

SECTION IV
DESIGN OF CANAL EXCAVATION SLOPES

4-01. GENERAL. - The design of the excavation slopes in the Long Sault Canal involves a study of the distribution and characteristics of the overburden materials, the effect of possible excavating methods, the choice of slopes which will require limited maintenance in the canal, and the consideration of adequate slope protection measures. The main factors governing the design are the characteristics of the overburden materials and the stress conditions to be produced by the removal of material from the canal.

4-02. GEOLOGICAL FEATURES AND CHARACTERISTICS OF OVERBURDEN.

(a) Distribution.- The overburden through which the canal will be excavated is variable and consists of marine clay, glacial till, and water-laid or partially water-laid sand. The geological origin of these materials is described in paragraph 1-02(a). Above Robinson Bay Lock the overburden is chiefly compact glacial till. An area of clay occurs along the canal alignment on Long Sault Island where canal excavation will vary in depth up to approximately 25 feet. In this area much of the surface is uniform silty fine to medium sand to depths from 0 to 8 feet. The variable sandy clay which is either exposed or underlies this sand overlies directly soft gray clay or glacial till at depths up to 20 feet. On the mainland above Robinson Bay Lock a few areas of clay also occur, but grade for the canal in these areas is expected to remain in the upper variable sandy clay so that there will be practically no excavation in the soft gray clay above the lock. Limited surface deposits of variable sand and gravel and at least one small deposit of stratified sand buried between layers of clay occur a short distance upstream from the lock. Below Robinson Bay Lock marine clay deposits overlie glacial till between ridges of glacial till. In some areas water-laid or partially water-laid sand deposits exist between the clay and the till, but these deposits are limited in extent and thickness and may be neglected in the design. The maximum depth of excavation in clay in the canal outside of lock excavation will be approximately 30 feet. The maximum excavation in till in the canal proper will be approximately 50 feet. The variation of the overburden is shown in geological profiles on Plates IV-1 to IV-9, and the classification of overburden at drill holes and auger holes and the records of probings are shown on Plates III-15 to III-38 and III-43 to III-47. The location of all exploration in the vicinity of the canal is shown on Plates III-5 to III-12.

(b) Characteristics of Clay Deposits.

(1) The clay overburden in the vicinity of the Long Sault Canal consists of firm variable sandy clay and of soft gray silty clay. In general, the variable sandy clay occurs in surface deposits up to 20 feet in depth overlying either the soft gray clay or glacial till. In a few local areas the sandy clay is covered by shallow deposits of uniform silty fine to medium sand such as occur on Richard's Point (Long Sault Canal Stations 60+00 to 70+00), on Long Sault Island, and in the vicinity of Station 210+00 and 230+00. A few very limited areas occur where shallow strata of sand or sand and gravel form a more pervious boundry Between the top sandy clay and the underlying soft gray clay. Maximum total depths of clay of approximately 75 feet were observed during exploration along the canal at points where from 5 to 20 feet of the brown sandy clay overlie the soft gray silty marine clay. No stratification is apparent within the two general classifications of clay. The water table in clay areas varies from the surface in certain swampy localities to depths of from 10 to 15 feet below the surface.

(2) Undisturbed samples taken in the Long Sault Canal from 6-inch drill holes D-1156 at the Grass River Lock site and D-1160 east of Robinson Bay Lock are considered to be representative in general of the clays throughout the canal. Observations of the sampling process and of the samples obtained and a study of the laboratory testing indicated that pockets of reduced strength occur in both the brown sandy clay and the soft gray clay. The occurances of these pockets usually appear to be with out correlation to locality, depth, or even water content. As explained in paragraph 3-04 (e), the results from triaxial tests for quick shear under applied lateral pressure are considered to be the most representative data on the strength of the clays as they occur in nature. Strength is greatly reduced when these clays are disturbed. Direct shear tests on remolded samples and liquid limit tests indicated that the soft gray clay is practically without strenght when it is remolded at its natural water content.

(3) Typical grain size curves for the brown sandy clay and the soft gray clay are shown on Plate IV-10. The gray clay often contains many small shells and particles of organic matter, and grain size curves indicate from 10 to 30 percent by weight of collodial sizes. The characteristics of the clay materials are summarized in the following tables.

	Brown, sandy clay	Gray Clay
Specific Gravity	2.70	2.73
Water Content (% dry weight)	35%	55 to 60%
Liquid Limit	51.6	47%
Plastic Limit	24%	30.5%
Wet Weight	110 pcf	103 pcf
Void Ratio	1.24	1.65
Design Shearing Strength (see paragraphs 3-04 and 3-05)	1200 pcf	600 pcf

The variation of water content in the gray clay is nearly constant for most of the depth as shown on Plates III-53 and III-54. Consolidation characteristics for typical samples are presented in the form of pressure-void ratio curves on Plates III-72 and III-73, and typical time-consolidation curves on Plates III-76 to III-79. Actual tests for the coefficient of permeability were omitted. However, the clays are very impervious and their average coefficient of permeability as computed from consolidation test data is approximately 0.0000001 cm. per second.

(c) Characteristics of Glacial Till.- The deposits of glacial till consist of fairly compact to compact clayey or silty gravelly sand with scattered cobbles and boulders. There is no evidence of sand lenses in the till. Where overburden occurs over the till it consists generally of clay. Local deposits of loose variable silty and gravelly sand cap the till ridges on Richards Point and where the canal cuts into the mainland at approximately Station 240 + 00. There are also variable sand and gravel deposits overlying the more compact till in the ridges just west of the Robinson Bay Lock. Usually the till near an exposed surface or the contact surface with clay contains less silt or clay than the underlying till. Within any deposit there may be considerable variation in the quantity of clay or silt which acts as a binder, but in general the till is less compact near the surface and the density increases with depth. Grain size curves considered typical for this material are shown on Plate IV-10. From the results of a few tests and examination of samples the unit wet weight of till in place is believed to average about 145 pounds per cubic foot. The specific gravity is approximately 2.74. No test for shearing strength or con-

solidation characteristics were made on samples of glacial till. Considerable experience and precedent exist in working with similar materials, and on this basis it is known that the shearing strength is greater than that represented by an angle of internal friction of 30 degrees. It is estimated that the coefficient of permeability of the glacial till in nature varies between 0.0001 and 0.0000001 cm. per second.

(d) Bedrock.- A sufficient amount of drilling and seismic exploration was completed to indicate that no rock excavation will be required for the construction of the canal proper. The general characterisitcs of bedrock in the vicinity of the Robinson Bay and Grass River Locks and at the guard gate are considered in the separate analyses of design for those structures.

4-03 ANALYSIS OF CANAL EXCAVATION SLOPES.

(a) General.- The excavation slopes selected for the canal are shown on sheets MC-1-10/28 through MC-1-10/34 of the contract drawings, and the analyses are on file at the district office. Slopes shown for excavation in firm material are considered to be satisfactory and final. The assigned slopes in clay are considered to be satisfactory but should be revised if the results from field tests and experience during construction give additional information relating to the clays which indicate that revisions are in order.

(b) Slopes in Soft Materials.

(1) The clay and sandy clay present in the canal area are termed "soft" materials this analysis of design and on the contract drawings. The stability of canal excavation slopes in areas of soft overburden materials depends upon the depth of excavation, the depth of the clays, the characterisitc of the clays, the effect of seepage forces, and the method of construction. The governing depths to firm materials and the critical depths of excavation in clay are indicated by the geological profiles on Plates IV-1 to IV-9. The characteristics of the clays are discussed in paragraph 4-02 (b). It is expected that dry excavation methods will be used for those portions of the canal covered by this analysis and that water level in the canal may be lowered for short periods after it is put into service. To meet these conditions which are equivalent to "sudden draw down" the canal was assumed to be dewatered in all analyses. It is also concluded that excavation in soft material should be made in a manner to prevent any failures during construction. The soft gray clay is practically without strength when seriously disturbed at its natural water content so that besides the possibility of danger to personnel and equipment excessive excavation would be necessary to provide the required canal section once failures had started. The basic method of analysis used in design was the "circular arc method" which assumes that a rapture surface will be in the form of a circular arc, the driving forces being taken as the effective weight of the soil mass and the pore water weight within the arc acting to produce rotation about the center of the arc's circle, and the resisting forces being taken as the sum of the cohesion acting along the arc and the friction on the arc under forces normal to it.

(2) Preliminary Studies.- Preliminary studies of the stability of canal slopes were conducted to give a working basis for design and to give preliminary results for conferences. These studies were made using the "method of slices" application of the circular arc type of stability analysis. The resisting and driving forces for the most dangerous circular sliding surface were determined for the case of sudden drawdown using the working assumption that the ground water elevation was at the surface. The shearing strength used for clay was based on results from triaxial consolidated quick shear tests (see Plate III-67), and preliminary values were assigned at cohesion equal to

500 pounds per sq.ft. and angle of internal friction equal to 9½ degrees for clay throughout without allowing for higher strength in the brown sandy clay at the surface. The saturated weight of material within the sliding segment was used in calculating driving forces, but only the submurged weight was considered effective in calculating frictional resistance to sliding. The results of these preliminary analyses are on file in the district office.

(3) Final Analyses.- To provide a basis for the final selection of excavation slopes in soft overburden materials in the canal new stability analyses were made using the ϕ-circle method. These analyses were made following a study of the preliminary results and following the decision that the shearing strength of the soft gray clay is substantially independent of depth and that results from triaxial quick shear tests made under lateral pressure give strength values most representative of the actual conditions in nature. The method described and curves presented in the paper entitled "Stability of Earth Slopes" by Professor D.W.Taylor, Journal of the Boston Society of Civil Engineers, July 1937 were used. Analyses were based upon excavation in the dry using a saturated weight of material equal to 110 pounds per cu.ft. and a shearing strength for all clay equal to 600 pounds per sq.ft. independent of depth. The limiting stability ratio for the final selection of slopes was set at 1.50, and the results from these studies are presented as curves on Plate IV-11. This plate which was used as a basis in assigning canal excavation slopes in clay areas shows for depths of cut up to 36 feet the cotangent of the maximum allowable slope under the conditions assumed plotted against total depth of clay. The maximum slope to be excavated in the canal was set at 1 on 2 to limit maintenance. Within the limits of the contract for the canal proper it was necessary to flatten slopes in clay overburden below this maximum only in the section extending east from Robinson Bay Lock for approximately 4000 feet. The slope through most of this section was set at 1 on 6.

(4) In order to insure against the effect of surcharge from spoil areas upon the stability of slopes in soft materials provisions are made in the specifications and contract plans to keep spoil areas at a satisfactory distance from canal excavation. Where soft materials exist along the canal a minimum distance of approximately 200 feet was maintained between top of slope at excavation and the toe of slope at the spoil area. The maximum depth to which spoil might be placed behind this limit was further restricted to 20 feet for an additional distance of 200 feet away from excavation.

(c) Slopes in Firm Materials.- The glacial till and water-laid sands which occur along the canal alignment are considered to be firm materials. Since the canal in the areas of firm materials will probably be dry during construction and possibly during short periods of operation the most critical general assumptions for stability are that the driving forces tending to cause shear failure are a function of the saturated weight of the material, and that the shearing strength is a function of the submerged weight of the material. Using the ϕ-circle method and the charts of D.W. Taylor referred to in paragraph 4-03 (b) (3) a simplified preliminary analysis indicated that the stability ratio, or ratio of the resisting forces to driving forces for shear failure along the critical circular arc, would be greater than 1.5 for the 50-foot maximum depth of canal cut out in till if slopes of 1 on 2 were provided. Since slopes of 1 on 2 have been selected for all heights of canal excavation in firm materials based upon experience with similar materials and general consideration of design and maintenance ample safety is provided against any major slide during and after construction. No further detailed analysis is considered necessary.

4-04. SLOPE PROTECTION. - Excavation slopes throughout the length of the canal will be largely submerged during regular operation. Of the slopes which

will not be submerged the most exposed will be in glacial till and the maximum height above preliminary pool elevation will be approximately 22 feet. In view of the adequate width of the canal, the character of the till, and the excavation slopes of 1 on 2 assigned in this material no special measures for slope protection are considered necessary. It is believed that there will be ample safety against major slides, and minor maintenance can be accomplished during operation of the canal without the interruption of regular traffic.

4-05. FUTURE ANALYSES. - The completed analyses are considered to be entirely adequate for the final assignment of canal slopes. However, future analyses should be undertaken if unexpected conditions are encountered during construction which might affect stability or maintenance or if results from field tests such as a test trench in clay differ substantially from the values used in this analyses.

SECTION V
DESIGN OF DIKE NO. 1

5-01. LOCATION. - A study of the general requirements for the dike system along the Long Sault Canal resulted in the adoption of dike locations shown on sheets MC-1-10/30 and MC-1-10/31 of the contract drawings. This dike is located along the south bank approximately parallel to the canal and serves to maintain pool operation levels in the canal above the guard gate. The dike has been located in areas with the most suitable foundation conditions.

5-02. GEOLOGICAL FEATURES AND CHARACTERISTICS OF FOUNDATION MATERIALS.

(a) The foundation overburden materials consist of glacial till, water-laid and partially water-laid sands, and marine clay. The variation of the overburden along Dike No. 1 is shown by the geological profile on Plates V-1 to V-3. Classification of the overburden at drill holes and auger holes is shown on Plates III-39 to III-42. Detailed reports for all drill holes, auger holes, probings, and test pits are on file in the district office. In general, the silty to clayey gravelly sand deposits (glacial till) occurring in the foundation area are quite impervious and the permeability decreases with depth. The estimated coefficient of permeability of the top few feet of the deposits is 0.0001 cm. per second below which the coefficient is probably reduced to 0.0000001 cm. per second. The glacial till in general is compact and has a high angle of internal friction.

(b) Two types of clays occur in the foundation area. In part of the area between stations 43 + 00 and 78 + 00 brown, fairly firm, sandy clay cover overlies soft grey marine clay. Between stations 3 + 00 and 20 + 00, soft grey marine clay underlies uniform sand. The soft grey marine clays have an average water content of approximately 55 percent dry weight. In general, the water content is greater than the liquid limit. Undisturbed samples have been taken from D-1399 near station 8 + 00 for shear and consolidation tests. These tests are not complete and the results will be placed in the office files. It is believed that the grey clay has a very low shearing strength, similar to the other soft clays which occur in the vicinity of the canal. Typical grain size curves of the clays and glacial till are shown on Plate V-4.

5-03. AVAILABILITY AND CHARACTERISTICS OF EMBANKMENT MATERIALS.

The materials for dike embankments will be obtained from canal excavation and from gravel deposits selected by the contractor. Canal excavation will be particularly heavy along this section and will provide the required selection of clayey or silty gravelly sand for earth fill. Grain size curves which are considered typical of the materials for the earth fill are shown, as shown for glacial till, on Plate IV-10. These materials can be easily and satisfactorily compacted, and when compacted as required in the specifications, it is estimated that the coefficient of permeability will be less than .0001 cm. per second, and that the angle of internal friction will be at least 35 degrees. Sand and gravel for backing under riprap will be obtained from suitable sand and gravel deposits of which there are a number within less than 15 miles from the site.

5-04. DESCRIPTION OF SECTION. - For the purpose of preparing contract drawings, the section shown on sheet MC-1-20/4 of the contract drawings was selected. At the time of selection, it was not known that a deep deposit of clay occurred between stations 3 + 00 and 20 + 00 and at several locations along the land side toe between stations 45 + 00 and 78 + 00. Slopes of 1 on 5 were chosen since there is ample suitable earth material available from the canal excavation. Due to the soft foundation clays, it may be necessary to change the slopes in some sections to produce ample foundation stability. The dike will actually be a spoil deposit for canal excavation material with a compacted section on the pool side. The front slope of Dike No. 1 will be protected with riprap which will be placed upon a sand and gravel backing except where the embankment material at the face contains a suitable proportion of gravel. To prevent seepage through the upper few feet of foundation in areas of relatively pervious foundation materials a cut-off trench is provided. It is expected that this trench will be required between stations 4 + 00 and 19 + 00 where the top foundation layers are a uniform silty fine to medium sand and may be required at other sections which will be determined in the field at the time of construction.

5-05. ANALYSIS OF SECTION. - No detailed analyses have been made for the embankment sections for the various foundation conditions. Such analyses was not considered necessary where the foundation material is silty gravelly sand (glacial till). The section which extends over clay areas should be analyzed for stability and the slopes should be altered if necessary. Shear test data for design of the section between station 3 + 00 and 20 + 00 will be placed on file as soon as the tests are completed. The use of a cut off trench was adopted for areas where slightly porous materials in the upper part of the foundation might permit excessive seepage. Filter blankets to control seepage were not considered necessary in view of the width of the section through the dike, and no special protection will be required at the back toe.

SECTION VI
DESIGN OF DIKE NO. 3

6-01. LOCATION. - Dike No. 3 which serves to maintain operating pool elevation on the south side of the canal from dike No. near the guard gate to Robinson Bay Lock is located as shown on sheets MC-1-10/31 and MC-1-10/32 of the contract drawings except east of station 70 + 00 which is shown on the contract drawings for Robinson Bay Lock. In order to place as much as possible of the embankment upon firm foundation materials the adopted location for Dike No. 3 swings away from the south canal bank where sizeable clay areas and lower elevations occur and crosses to the till ridges at some distance from the canal. This alignment crosses two major areas of clay between Stations 0 + 00 and 19 + 50 and between Stations 50 + 00 and 56 + 00 but otherwise provides a relatively good foundation.

6-02. GEOLOGICAL FEATURES AND CHARACTERISTICS OF FOUNDATION MATERIALS.

(a) General. - The foundation overburden materials consist of glacial till, water-laid and partially water-laid sands, marine clay, and beach deposits. The variation in overburden is shown by a geological profile along the centerline of the dike on Plate VI-1. The classification of overburden at drill holes and auger holes is shown on Plates in Section III and detailed reports for each drill hole, auger hole, probing and test pit are on file in the district office. The foundation from stations 0 + 00 to 19 + 50 and 50 + 00 to 56 + 00 consists of clay overlying water-laid deposits of sand which, in turn, are underlain by compact silty to clayey gravelly sand. The variable sands underlying the clay are relatively pervious compared to the clay and to the underlying silty to clayey gravelly sand. The coefficient of permeability of the variable sands may be as great as 5 x 10-4.cm. per second. The maximum depth of clay in the dike foundation area between Stations 0 + 00 and 19 + 50 is 57 feet at the centerline between Stations 50 + 00 and 56 + 00 is 20 feet. A contour map of the firm material between stations 0 + 00 and 19 + 50 is shown on Plate VI-2. The results of testing to determine the characteristics of the clays at these two locations are presented in paragraph 6-02(b) below. The foundation overburden in other sections of the dike consists of compact glacial till except for small variable beach deposits of sand and gravel between Stations 63+ 00 and 67+ 00 and Stations 72 + 00 and 77 + 00, and a shallow clay deposit between Stations 68 + 00 and 70 + 00. Typical grain size curves for the foundation materials are shown on Plate VI-3. The glacial till is, in general, very compact. However, the compactness and the density depend upon the percentage of clay and silt particles present. The upper portion of the till deposits, to a depth of approximately 5 feet, usually contains a smaller proportion of silt and clay sizes with the result that this material is more pervious and has an estimated coefficient of 0.0001 cm. per second as compared with a coefficient of approximately 0.0000001 cm. per second for the underlying till. Because there has been considerable experience in the construction of earth embankments upon foundations similar to the firm overburden materials to be found at this dike site no extensive program of soil testing was considered necessary except for the clays. The general characteristics of glacial till described in paragraph 4-02 (c) for the canal excavation may be considered to apply to till foundation at Dike No. 3.

(b) Characteristics of Clay. - The two important areas of clay in the foundation area of Dike No. 3 mentioned above occur between Stations 0+00

and 19 + 50 and between Stations 50 + 00 and 56 + 00. Plate VI-3 shows typical grain size curves for the clays which occur in the areas. A summary of routine test results for clay samples from D-1243 is presented. on Plates III-55, III-57, and III-58. Water content determinations for samples from the upper 8 feet where the clay contains scattered sand pockets and some dispersed sand show a range between 29.3% and 37.9%. Below 8 feet the water content of the clay appears to be independent of depth and varies generally between 45% and 55% of dry weight with an average of approximately 49%. The results of consolidation tests on undisturbed samples from D-1243 are summarized as pressure-void ratio curves on Plate III-74. Typical time-consolidation curves appear on Plate III-80. An average coefficient of permeability computed from the consolidation test data is approximately 0.000001 cm. per second. The results from triaxial tests on undisturbed samples for both quick shear and consolidated quick shear are shown on Plates III-64, III-65, and III-70. A typical stress-strain curve is presented on Plate III-61. As explained in paragraph 3-04 (d) the results from tests for quick shear are considered to be the most representative data on the strength of the clay as it occurs in nature. On this basis a value of 540 pounds per sq. ft., independent of depth, was adopted as the strength of the clay for the final analysis of this section. The results of tests on samples from drill hole D-1279 were used to indicate the characteristics of the clay in the second clay area between Stations 50 + 00 and 56 + 00. This material appears to have greater strength in its natural state than that at D-1243, and a conservative value of 800 pounds per sq. ft., independent of depth, was adopted for the final design. Plates III-65 and III-71 show the results from triaxial tests for quick shear and consolidated quick shear run on samples from D-1279, and the pressure-void ratio curves for consolidation tests of undisturbed samples appear on Plate III-75. A summary of the results from routine tests upon samples from hole D-1279 is presented on Plates III-57 and III-58. Water content determinations fell chiefly between 40% and 56% of dry weight with the average near 54%. The estimated coefficient of permeability is approximately 0.0000001 cm. per second.

6-03. AVAILABILITY AND CHARACTERISTICS OF EMBANKMENT MATERIALS. - Materials for the dike embankments will be obtained from the canal excavation and from gravel deposits selected by the contractor. Materials for the earth fill section of the dikes will be clayey or silty gravelly sand obtained by selection from the canal excavation. In case additional borrow is required for earth fill beyond what can economically be obtained from the canal excavation it may be obtained from borrow areas in the till ridge to the south of Dike No. 3. The grain size curves which are considered typical of the materials for earth fill are shown on Plate IV-10. These soils can easily and satisfactorily be compacted, and when compacted, as stated in the specifications it is estimated that the coefficient of permeability will be less than 0.0001 cm. per second and that the angle of internal friction will be at least 35 degrees. For purposes of design a unit weight of 125 pounds per cu. ft. is considered satisfactory for earth fill in place in the embankment. Pervious materials for filter blankets and sand and gravel for backing under riprap will be obtained from sand or sandy gravel deposits. Small superficial deposits of sand and gravel containing material which is believed to be suitable occur within 15 miles of the site. Material for the rock toe fillet and for riprap will be obtained by stone removal from earth fill sections of the embankments and borrowed from excavations for other structures of the project.

6-04. DESCRIPTION OF THE SECTION.

(a) General. - Dike No. 3 will be an earth fill with a minimum

top width of 35 feet which may be used as a future roadway. At the eastern end of the dike where it will approach and tie to the structure of the Robinson Bay Lock, Dike No. 3 will be used as a railroad approach to the lock. The top of the dike is at elevation 254.5. Sufficient freeboard is believed to be provided at maximum pool elevation against overtopping by waves under maximum conditions where the canal pool will be wide providing long fetches to the wind. Typical sections for the dike are shown on sheets MC-1-20/4 and MC-1-20/5 of the contract drawings except for that portion which is included in the contract for Robinson Bay Lock.

(b) Sections on Firm Foundation. - The typical section on a firm foundation will have an impervious core of compacted Class I earth fill (see Paragraph 3-06 of the Long Sault Canal and Dike Specifications) between front and back sections of compacted ClassII earth fill. The reservoir slope will be 1 on 3 and will be protected against erosion by riprap to a depth of 3 feet. The riprap will be placed upon a sand and gravel backing except where the fill contains sufficient gravel at its surface to make the use of the backing unnecessary. The land slope will be 1 on $2\frac{1}{2}$ and will be seeded. Where the height of dike exceeds 10 feet a cut-off trench under the core will be used wherever necessary to intercept excessive seepage through any more pervious surface layer of the foundation which may be encountered. When the height of dike exceeds 10 feet a filter blanket will also be used to a depth of 2 feet under the Class II fill at the back of the dike, and the back toe will be protected with riprap as indicated on the typical sections.

(c) Sections on Soft Foundation.

(1) Dike sections to be constructed upon clay between stations 0 + 00 and 19 + 50 include transition sections and the typical sections shown on sheet MC-1-20/5 of the contract drawings.
These sections are to consist of a central core of compacted earth fill set between front and back sloping berm sections of dumped fill. The shape and base width of the sections are governed by foundation conditions. Because of the large width of the embankment between Stations 0 + 00 and 19 + 50 no filter blanket and no special protection at the back toe are considered necessary. Required stripping is limited to a width of 100 feet at the centerline. The reservoir slope will be protected above elevation 244.0 by riprap placed upon a sand and gravel blanket where required. The top 3 feet of the reservoir berm slope of 1 on 20 will be gravelly material to prevent excessive erosion when it is submerged.

(2) The dike section between Stations 50+ 00 and 58 + 50 will have a central core of compacted Class I earth fill between sections of Class II fill flanked by sloping berm sections of dumped fill below elevation 235.0. The reservoir slope above elevation 235 will be protected by riprap. A cut-off trench will be provided under the core where required and a sand and gravel filter will be used under the Class II and Class III fill on the land side of the dike. A sand and gravel drain, 20 feet wide, extends from the filter blanket to the land side toe.

6-05. ANALYSIS OF SECTIONS.

(a) General. - The selection of suitable sections for Dike No. 3 involved the usual major considerations of limiting elevations and dimensions, the strength of foundation materials, the design of stable embankment sections using the economically available materials, the question of consolidation in both the foundation and embankment, and the control of seepage forces and losses. The top elevation of canal dikes above the Robinson Bay Lock has been

set at elevation 254.5. With the pool preliminary operating level above Robinson Bay Lock at elevation 238.0 and ultimate pool level planned for elevation 242.0 sufficient freeboard is considered to be provided against overtopping by waves and against maximum high water conditions. The maximum height of embankment required for this dike will be 40 feet. Data on the strength and characteristics of foundation and embankment materials are discussed in paragraphs 6-02 and 6-03 above. Since foundation materials of two entirely different ranges of strength occur at the site the problem of design was separated into two parts: the selection of embankment sections to be placed upon firm foundations such as deposits of glacial till and the selection of sections to be built upon soft foundation areas of clay.

(b) Sections on Firm Foundation. - Detailed analysis are not considered necessary for the sections adopted for use upon firm materials. Experience with similar materials and sections indicates that ample safety for stability has been provided, and that the quantity of seepage will be very small. When the height of the dike exceeds 10 feet a filter blanket will be used under the back slope to control seepage and the back toe will be protected by riprap. A cut-off trench will also be utilized where necessary. Settlement of the foundation will be negligible. Consolidation of the embankment will occur largely during the construction period, and sufficient top width is provided to permit capping to correct for the minor settlement which will occur later.

(c) Sections on Soft Foundations.

(1) Preliminary Studies. - As the exploration and testing programs progressed, indicating the extent and characteristics of the two major clay areas along the dike, the decision was made that to remove the clay or to sink the dike in these areas would not be practical. First, a preliminary section for the embankment upon clay was assigned (April 18, 1941) with 1 on 3 slopes on the back slope and on the front slope above elevation 225.0 and 1 on 4 below that point. An impervious central core was provided, and sand and gravel filter blankets under the front and back slopes were to be used to accelerate consolidation by providing surface drainage for the foundation. This section was superceded when a revision of the dike alignment was made and more complete foundation exploration indicated depths of clay up to 57 feet between Stations 0 + 00 and 19 + 50. Studies were next undertaken to determine to what height the dike could be built with slopes of 1 on 5 using a minimum allowable stability ratio of 1.25 and strength values for clay based upon the results of triaxial consolidated-quick shear tests (see Plate III-70). Cohesion was taken equal to 500 pounds per sq. ft. and the angle of internal friction equal to 11½ degrees for the clay. For the earth fill of the embankment unit moist weight was taken at 125 pounds per cubic foot, cohesion equal to zero, and the angle of internal friction equal to 30 degrees. The "method of slices" application of the circular arc theory of failure was employed, and the 25-foot stages were analysed, as well as the full height of 40 feet. On this basis it appeared that the dike might be constructed to the 30-foot stage before the minimum stability ratio of resisting forces to driving forces would fall below 1.25. With the decision that the results of quick shear tests under applied lateral pressure are the most indicative of values for the natural strength of the clay (see paragraph 3-04) (e) the design values were revised to use a strength equal to 540 pounds per sq. ft. independent of depth for this section between Stations 0 + 00 and 19 + 50. Preliminary analyses showed that comparatively flat slopes were required for the embankment on deep clay with the result that composite bermed slopes were investigated using first the conventional method of slices and next a mathematical analysis based upon the circular

arc theory of failure. At this point in the design of dikes a slightly increased value of 35 degrees was adopted for the angle of internal friction for materials in place in the dike embankment and the minimum stability ratio required was set at 1.50. The determination of shearing stresses in the foundation and at a rigid boundary by methods developed by Dr. Leo Jurgenson (see "The Application of Theories of Elasticity and Plasticity to Foundation Problems," Journal of Boston Society of Civil Engineer, July 1934) and by the Corps of Engineers at Fort Peck, Montana (see explanations and tables under Chapter 8, "Notes on Principles and Applications of Soil Mechanics," U.S. Engineer Office, Fort Peck, Montana, June 1939) was used as a check upon the results from the mathematical analyses. Following a review of preliminary results up to that point, a series of studies were undertaken by the method of slices using a flat berm at elevation 246.0. This led directly to the final design discussed in paragraph (2) below, Preliminary studies of embankment sections for the dike on soft foundation between Stations 50 + 00 and 56 + 00 were less extensive but followed the same general pattern except that a strength value of 800 pounds per sq. ft. for the clay was used throughout, independent of depth. The results of all analyses are on file in the district office.

(2) Final Analyses.- Final stability analyses for dike No. 3 sections on soft foundation materials were carried out using the method of slices and setting the minimum allowable stability ratio of resisting forces to driving forces at 1.50. The foundation and embankment characteristics assumed are presented in paragraphs 6-02 (b) and 6-03. Summary sheets for stability analyses performed for the finally adopted sections appear on Plates VI-4, VI-5, and VI-6. A typical computation for these stability analyses is shown on Plate VI-7. The final sections were designed to require as little riprap as possible, this type of protection being confined to the upper 1 on 2½ slope on the front. The 1 on 20 slope for the berms was considered to be sufficiently flat to prevent harmful erosion on the pool side where most of the berm will be submerged. The sections between Station 0 + 00 and 19 + 50 are sufficiently wide so that the problem of see page is considered negligible and no protection of the back toe will be required. Because of the comparatively great depth of very impervious clays under this part of the dike it is not believed that settlement of the foundation can be accelerated to any valuable extent by providing filter blankets for the drainage of expelled pore water at the top of the foundation. Such blankets were therefore omitted under this section of the dike. A rough check of the settlements up to a maximum of 5 feet. Complete settlement analyses including consolidation within the embankment were not undertaken. Between Stations 50 + 00 and 58 + 00 where the cross section of the dike on clay is somewhat less wide a filter blanket and back toe protection are to be used to control against the possible effects of see page and a cut-off trench is to be provided where necessary.

6-06. FUTURE ANALYSES. - After additional exploration is conducted and additional studies are made to determine the shearing strengths of the foundation clays, the sections between Stations 0 + 00 and 19 + 50 and between 50 + 00 and 58 + 00 should be checked for statical stability. Final design for all sections of the dike on firm material is considered complete.

6-07. ECONOMY OF CONSTRUCTION. - In the design of the dike sections, considerations were given to the locations and quantity of available suitable material for construction. It is believed that ample material will be obtained

from the canal excavation for the section between Stations 0 + 00 and 70 + 00 and from the Robinson Bay Lock excavation for the section beyond Station 70 + 00. The wide berms of the dike sections on clay foundations will be composed of random fill and will not be compacted.

SECTION VII
DESIGN OF DIKES NOS. 5 AND 6

7-01. LOCATION OF DIKES NOS. 5 AND 6.- A study of the general requirements for the canal dike system resulted in the adoption of the locations for Dike Nos. 5 and 6 shown on sheets MC-1-10/33 and MC-1-20/1 of the contract drawings. Dike No. 5 approximately parallels the canal between Stations 406 00 to 429 00 at some 3,000 feet to the south. Dike No. 6 is opposite to the north, between the canal alignment and Robinson Bay. At these locations minimum quantities of suitable embankment materials may be used, and relatively favorable conditions exist.

7-02. GEOLOGICAL FEATURES AND CHARACTERISTICS OF FOUNDATION MATERIALS.

(a) No detailed foundation exploration was considered necessary at the final adopted alignment for Dike No. 5. A few auger borings in the vicinity indicate that the foundation is a sandy clay overlying a softer clay. However, the maximum height of embankment on this foundation will be 10 feet only. Plate VII-1 presents a geological profile for Dike No. 5. Typical grain size curves of the foundation material are shown on Plate VII-2.

(b) A geological profile at the centerline of Dike No. 6 is presented on Plate VII-1. The overburden consists in general of uniform fine to medium sands overlying clay to a depth of approximately 10 feet. Typical grain size curves are shown on Plate VII-3. The estimated coefficient of permeability for these sands is 0.0001 cm. per second. The depth of the underlying clay is variable but is known to exceed 40 feet at certain probings along the dike alignment. Specific tests were not run on samples of this clay, but its general characteristics are considered similar to those of the soft materials found in canal excavation areas and described in paragraph 4-02 (b). Since Dike No. 6 will be at its maximum height where it crosses the existing channel of Robinson Creek the depth of clay in that vicinity was more thoroughly investigated by probing. Elsewhere embankment heights do not exceed 18 feet. The abutments at Robinson Creek and certain areas hear the eastern end of the dike consist of well graded silty to clayey gravelly sand which in general is quite impervious. However, the top few feet may be somewhat variable and more pervious.

7-03. AVAILABILITY AND CHARACTERISTICS OF EMBANKMENT MATERIALS.-

The materials for the dike embankments will be obtained from the canal excavation and from gravel deposits selected by the contractor. Materials for the earth fill section of the dikes will be similar and available to those described in paragraph 6-03.

7-04. DESCRIPTION OF SECTIONS.

(a) Dike No. 5. - Dike No. 5 will be compacted Class 1 earth fill of suitable material obtained from excavation. The top width will be at least 15 feet. The front slope of 1 on 3 will be protected against erosion by riprap placed upon a suitable sand and gravel backing where required. The back slope of 1 on 2½ will be protected by seeded topsoil. A typical section is

shown on sheet MC-1-20/4.

(b) Dike NO. 6. - Where the height of embankment is less than 18 feet Dike No. 6 will be constructed similar to those sections of Dike No.3 on firm foundation materials described in paragraph 604. In the vicinity of Robinson Creek where the height of Dike No. 6 will exceed 18 feet the section shown on Sheet MC-1-20/5 of the contract drawings will be used. This section provides an additional sloping berm with a slope of 1 on 20 between elevation 185.0 and elevation 190.0 on both front and back of the embankment.. Slopes below elevation 185.0 will be 1 on 2½ and above elevation 190.0 will be the same as for other sections of the dike. The reservoir slope will be protected by riprap above the sloping berm, the top of which will be selected material to a depth of 3 feet. To control seepage through the embankment and foundation a filter blanket is provided under the Class II fill at the back of the section. This filter blanket will be drained by a sand and gravel filter-drain 20 feet wide extending to the back toe in the bottom of the present channel of Robinson Creek at approximately Station 2 +-70 for the dike.

7-05. ANALYSIS OF SECTIONS. - No detailed analyses have been made of embankment sections assigned for Dikes Nos. 5 and 6. The heights of embankment required are relatively low except at Robinson Creek on Dike No. 6. Based on experience with similar materials and sections, it is considere that the sections assigned have ample safety for stability and that the quantity of seepage will be small. The design studies for sections of Dike No. 3 were of some value as guides in assigning the section at Robinson Creek. Foundation and embankement settlements have not been computed, but are not expected to be important on Dikes Nos. 5 and 6. Since an interim period will exist after the completion of the dikes and before regular operating conditions in the canal are established there will be an opportunity to observe settlement and seepage conditions and to take corrective measures it necessary.

LONG SAULT CANAL

ANALYSIS OF DESIGN

PLATES

NOTE:
Dikes as shown are for Alternate "E"

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

ALIGNMENT STUDIES

IN 1 SHEET — SCALE 1" = 2500 FT.

1000 0 5000 FT.

U.S. ENGINEER OFFICE, MASSENA, NEW YORK MARCH, 1942

SUBMITTED: W.F. Sperling, SENIOR ENGINEER; A.F. Sifer, HEAD ENGR.; C. Bissell, LT. COL. CORPS OF ENGINEERS; A.R. Jones, DIVISION ENGINEER, CORPS OF ENGINEERS, DISTRICT ENGINEER

Drawn by: J.A.H.
Checked by W.F.S.

FILE NO. MC-A-190/1

TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 1942

ST LAWRENCE RIVER PROJECT

LONG SAULT CANAL

DRILL HOLES

Drill Hole No.	Coordinates N	E	Elevation top of Hole	Elevation top of Rock	Feet of Rock Drilled
D 1069	1,814,680	359,481	225.6	159.1	20.0
D 1070	1,814,198	367,946	200.1	136.2	20.9
D 1071	1,817,747	380,536	185.6	90.5	23.1
D 1124	1,814,298	366,616	206.8	155.9	20.4
D 1125	1,817,681	384,832	180.3	119.4	23.5
D 1126	1,817,951	385,959	178.6	109.8	20.4
D 1141	1,818,405	385,417	179.8	100.4	27.6
D 1142	1,817,872	385,451	177.2	111.9	20.0
D 1143	1,816,036	383,094	186.6 N.R.	146.6	
D 1144	1,817,549	378,779	184.7 N.R.	144.7	
D 1145	1,817,366	377,026	187.1 N.R.	136.1	
D 1146	1,816,280	375,580	222.5 N.R.	172.2	
D 1147	1,816,484	373,573	207.6 N.R.	135.6	
D 1148	1,815,335	368,297	199.7	144.7	19.0
D 1149	1,815,229	367,800	205.3	138.7	20.4
D 1150	1,815,232	367,475	225.1	134.6	20.0
D 1151	1,816,071	362,962	214.6 N.R.	174.6	
D 1152	1,814,691	360,583	240.8	144.6	18.9
D 1153	1,815,192	358,124	227.4	156.0	20.0
D 1154	1,815,590	356,467	229.2 N.R.	189.2	
D 1155	1,814,606	356,686	224.8 N.R.	161.8	
D 1156**	1,817,882	385,451	177.2 N.R.	117.7	
D 1156-A**	1,817,872	385,461	177.2 N.R.	140.7	
D 1156-B**	1,817,882	385,431	177.2 N.R.	117.4	
D 1157	1,816,050	371,395	203.3 N.R.	152.3	
D 1158	1,815,765	370,130	198.0 N.R.	145.0	
D 1160**	1,815,632	369,480	197.0 N.R.	121.6	
D 1160-A**	1,815,617	369,480	197.0 N.R.	146.4	
D 1160-B**	1,815,636	369,528	197.0 N.R.	122.0	
D 1166	1,813,296	356,985	225.8 N.R.	155.8	
D 1167	1,813,364	359,428	218.4	163.4	20.3
D 1168	1,812,804	360,111	215.4	151.8	20.4
D 1169	1,812,389	360,604	217.2 N.R.	147.2	
D 1170	1,812,369	362,675	224.8 N.R.	154.8	
D 1171	1,812,856	363,666	216.7 N.R.	146.7	
D 1172	1,815,823	365,127	211.4 N.R.	141.4	
D 1173	1,815,075	365,845	261.8 N.R.	197.8	
D 1174	1,816,330	374,527	195.2 N.R.	124.2	
D 1175	1,818,917	383,525	189.3 N.R.	146.3	
D 1177	1,813,053	359,383	217.7 N.R.	179.0	
D 1178	1,812,661	359,828	215.8 N. R.	165.3	
D 1179	1,812,285	360,255	215.5 N.R.	171.9	
D 1180	1,813,313	359,960	216.8 N.R.	180.2	
D 1181	1,812,881	360,457	214.9 N.R.	153.7	
D 1182	1,814,727	359,002	225.5	165.9	20.2
D 1183	1,815,106	359,388	228.5	160.4	20.1
D 1184	1,814,726	359,742	226.3	153.9	20.0
D 1185	1,815,024	359,779	227.3	154.3	20.2
D 1186	1,814,943	360,171	232.8	144.6	20.0
D 1187	1,814,433	360,065	227.9	151.0	20.1
D 1188	1,814,563	365,465	252.6 N.R.	207.6	
D 1189	1,813,840	366,391	246.0	145.6	21.3
D 1190	1,815,091	366,673	246.5	145.2	22.6
D 1191	1,814,921	366,865	228.8	140.1	18.8
D 1192	1,815,155	367,048	238.1	137.9	20.1
D 1193	1,814,991	367,279	208.5	131.1	20.4
D 1194	1,815,059	367,673	202.4	140.0	20.7
D 1195	1,815,126	368,067	198.6	145.4	20.0
D 1196	1,817,857	384,066	184.8	104.8	20.0
D 1197	1,816,113	384,377	185.6	94.1	25.3
D 1198	1,817,941	384,559	184.3	109.6	27.0
D 1199	1,818,180	384,772	184.7	92.6	23.1
D 1200	1,818,011	384,973	183.4	105.4	22.2
D 1201	1,818,247	385,166	182.3	103.3	20.0
D 1202	1,818,079	385,367	175.3	110.0	20.4
D 1203	1,818,315	385,560	175.6	103.6	20.0
D 1204	1,818,146	385,761	177.7	109.2	20.1
D 1205	1,818,382	385,954	177.9	109.8	22.4
D 1209	1,818,309	387,438	154.2	112.2	20.0
D 1210	1,818,[illegible]	387,955	154.2	102.2	20.0
D 1211	1,818,410	388,029	154.2	111.2	20.0
D 1212	1,818,511	388,621	154.2	113.3	20.0
D 1213	1,818,612	389,212	154.2	106.0	20.0
D 1214	1,817,868	383,655	185.7	95.4	20.0
D 1215	1,817,821	383,260	185.5	103.1	20.8
D 1216	1,817,753	382,866	179.4	96.4	21.2
D 1217	1,813,721	358,981	229.8 N.R.	189.8	
D 1218	1,814,317	359,366	224.8 N.R.	184.8	
D 1219	1,812,117	360,903	229.6 N.R.	189.3	
D 1221	1,812,750	363,410	217.0 N.R.	177.0	
D 1222	1,812,906	363,841	218.3 N. R.	177.3	
D 1223	1,813,001	364,099	228.8 N.R.	188.8	
D 1224	1,816,412	362,669	227.2 N.R.	184.7	
D 1225	1,816,388	362,921	215.4 N.R.	145.4	
D 1226	1,816,286	363,170	215.7 N.R.	165.5	
D 1227	1,816,277	363,389	224.1 N.R.	183.6	
D 1228	1,815,958	364,509	229.5 N.R.	188.6	
D 1229	1,815,884	364,800	212.3 N.R.	165.3	
D 1230	1,815,950	365,110	210.9 N.R.	155.9	
D 1231	1,815,697	365,027	211.2 N. R.	158.5	
D 1232	1,815,706	365,487	226.2 N.R.	186.2	
D 1233	1,814,032	365,309	237.9 N.R.	207.9	
D 1234	1,813,775	365,051	235.5 N.R.	203.5	
D 1235	1,813,342	356,788	222.9 N.R.	172.9	
D 1236	1,816,439	363,104	212.8 N.R.	162.3	
D 1237	1,817,065	371,398	170.0	124.2	20.0
D 1242**	1,816,025	365,010	209.5 N.R.	155.0	
D 1242-A**	1,816,021	365,000	209.6 N.R.	176.2	
D 1243**	1,812,277	359,744	214.8 N.R.	176.3	
D 1261	1,818,011	383,898	185.6	97.5	19.8
D 1262	1,818,057	384,169	185.7	90.9	102.4
D 1266	1,813,360	358,610	231.1	156.1	22.8
D 1279**	1,812,853	363,657	216.7 N.R.	206.6	
D 1279-A**	1,812,845	363,659	215.7 N.R.	201.6	
D 1279-B**	1,812,850	363,673	215.7 N.R.	197.7	
D 1302	1,817,990	384,045	185.5	86.5	105.9
D 1303	1,817,805	383,770	184.6	86.4	202.5
D 1304	1,817,798	383,721	184.4	86.8	99.4
D 1365	1,817,681	384,228	183.2	111.3	20.0
D 1366	1,817,732	384,523	182.7	114.2	20.0
D 1367	1,817,899	384,312	184.9	107.4	63.0
D 1368	1,817,651	383,992	184.9	108.9	188.0
D 1369	1,817,814	383,901	184.5	100.0	100.0
D 1392	1,814,806	365,596	253.3	142.2	20.2
D 1393	1,814,856	365,892	254.8	140.9	20.0
D 1394	1,814,907	366,187	253.9	142.3	19.3
D 1399	1,811,150	351,900	226.2 N.R.	175.4	

** 6 drill holes with undisturbed samples
N. R. No Rock

FILE NO. MC-A-2/1
PLATE III-1

ST LAWRENCE RIVER PROJECT
LONG SAULT CANAL
DRILL HOLES, AUGER BORINGS & HAND PROBINGS
WITH NUMBERS GREATER THAN 1500

Drill Hole No.	Coordinates N	E	Elevation
T-1500-A	1,815,229	356,247	227.6
T-1501-A	1,815,539	356,924	229.5
T-1502-A	1,815,106	356,834	228.2
T-1503-A	1,815,416	357,512	228.3
T-1504-A	1,814,984	357,421	228.6
T-1505-A	1,814,861	358,009	226.9
T-1506-A	Hole Cancelled		
T-1507-A	1,815,171	358,686	227.3
D 1508	1,814,441	359,147	226.3
D 1509	1,814,339	359,636	223.7
D 1510	1,815,269	359,830	230.2
D 1511	1,814,237	360,126	228.4
T-1512-A	Hole Cancelled		
T-1513-A	1,814,194	361,205	215.6
T-1514-A	1,814,661	361,134	217.1
T-1515-A	1,814,556	361,827	214.7
T-1516-A	1,815,085	361,729	214.0
T-1517-A	1,814,086	362,696	220.1
T-1518-A	1,814,561	362,615	218.9
T-1519-A	1,814,594	363,045	219.6
T-1520-A	1,814,159	363,119	223.4
T-1521-A	1,814,260	363,711	216.7
T-1522-A	1,814,695	363,637	232.0
T-1523-A	1,814,796	364,228	217.0
T-1524-A	1,814,361	364,302	215.5
T-1525-A	1,814,897	364,819	215.5
T-1526-A	1,814,462	364,894	231.4
T-1527-A	Hole Cancelled		
T-1528-A	Hole Cancelled		
T-1529-A	Hole Cancelled		
D 1530	1,814,861	367,297	201.6
D 1531	1,814,870	367,756	200.5
D 1532	1,814,909	367,983	199.3
D 1533	1,815,372	368,025	204.8
D 1534	1,815,079	368,511	197.9
D 1535	1,815,488	368,644	198.1
T-1536-A	1,815,182	369,113	197.3
1537	Hole Cancelled		
T-1538-A	1,815,273	369,645	197.5
T-1539-A	1,815,373	370,237	117.0
T-1540-A	1,815,483	370,877	198.3
T-1541-A	1,815,910	370,754	181.3
D 1542	1,815,580	371,449	198.9
D 1543	1,815,676	372,011	200.4
D 1544	1,816,126	372,015	205.2
D 1545	1,810,213	372,528	202.1
D 1540	1,815,777	372,602	202.2
D 1547	1,810,314	373,119	200.5
D 1548	1,815,878	373,194	200.6
T-1549-A	1,815,979	373,785	197.3
D 1550	1,810,415	373,711	203.8
T-1551-A	1,810,910	374,302	195.5
T-1552-A	1,810,080	374,377	197.4
T-1553-A	1,816,131	374,642	200.8
T-1554-A	1,810,150	374,820	206.6
T-1555-A	1,816,374	374,783	198.4
D 1556	1,810,017	374,894	197.8
T-1557-A	1,810,399	374,931	207.7
D 1558	1,810,181	374,908	213.9
D 1559	1,816,718	374,485	213.2
D 1560	1,810,819	376,077	208.6
D 1561	1,816,383	376,131	215.2
T-1562-A	1,810,847	376,244	198.9
T-1563	1,810,629	376,281	203.0
T-1564-A	1,816,412	376,319	207.8
T-1565-A	1,810,869	376,372	196.7
T-1566-A	1,816,651	376,410	199.2
T-1567	1,810,442	376,490	200.4
T-1568-A	1,816,920	376,008	194.3
D 1569	1,816,484	376,742	199.6
T-1570-A	1,817,021	377,200	190.8
D 1571	1,810,585	377,334	199.1
T-1572-A	1,817,122	377,851	189.2
T-1573-A	1,810,880	377,925	191.4
T-1574-A	1,817,222	378,442	187.2
T-1575-A	1,810,787	378,517	190.4
T-1576-A	1,816,803	378,960	191.3
T-1577-A	1,817,323	379,034	185.2
T-1578-A	1,817,007	379,088	188.4
D 1579	1,810,888	379,108	193.7
T-1580-A	1,817,424	379,625	183.2
T-1581-A	1,817,207	379,662	186.2
T-1582-A	1,817,108	379,679	189.9
D 1583	1,810,989	379,700	195.4
T-1584-A	1,817,525	380,217	181.8
T-1585-A	1,817,308	380,264	188.3
T-1586-A	1,817,209	380,271	196.2
D 1587	1,817,090	380,291	203.1
T-1588-A	1,817,643	380,907	180.1
T-1589-A	1,817,425	380,944	180.8
T-1590-A	1,817,327	380,901	192.5
D 1591	1,817,191	380,883	197.9
T-1592-A	1,817,727	381,400	178.9
T-1593-A	1,817,509	381,437	185.4
T-1594-A	1,817,411	381,454	188.4
D 1595	1,817,292	381,474	192.4
T-1596-A	1,817,828	381,991	176.3
T-1597-A	1,817,010	382,028	183.9
T-1598-A	1,817,512	382,045	189.4
D 1599	1,817,392	382,065	200.9
T-1600-A	1,817,920	382,526	183.6
T-1601-A	1,817,474	382,519	182.7
D 1602	1,817,573	383,120	174.8

Drill Hole No.	Coordinates N	E	Elevation
T-1603-A	1,818,097	383,568	186.5
D 1604	1,817,722	383,632	184.5
D 1605	1,818,169	383,863	186.3
D 1606	1,817,603	384,363	181.9
D 1607	1,818,451	384,573	185.9
D 1608	1,818,535	385,066	184.1
D 1609	1,817,650	385,826	177.8
D 1610	1,818,678	385,904	177.9
D 1611	1,818,517	386,388	179.2
D 1612	1,818,886	386,528	179.8
D 1613	1,818,426	386,809	176.7
D 1614	1,818,745	387,363	180.3
T-1615-A	1,816,105	374,524	197.2
T-1616-A	1,816,566	374,598	191.5
T-1617-A	1,817,803	377,297	193.7
T-1618-A	1,816,853	377,592	191.9
T-1619-A	1,816,904	377,888	189.9
T-1620-A	1,814,411	364,598	220.9
T-1621-A	1,814,666	364,778	220.1
T-1622-A	1,814,933	365,028	225.7
T-1623-A	1,815,749	363,950	224.5
T-1624-A	1,814,360	363,694	220.9
T-1625-A	1,815,248	363,644	219.9
T-1626-A	1,814,860	367,230	204.3
T-1627-A	1,814,928	367,624	201.3
T-1628-A	1,815,012	367,609	202.1
T-1629-A	1,814,995	368,019	199.4
T-1630-A	1,815,213	367,981	200.5
T-1631-A	1,815,481	368,240	210.3
T-1632-A	1,815,532	368,536	139.1
T-1633-A	1,815,578	362,946	216.9
T-1634-A	1,814,206	362,675	217.6
T-1635-A	1,814,070	362,597	217.4
T-1636-A	1,815,362	368,260	199.1
T-1637-A	1,814,249	360,946	216.1
T-1638-A	1,814,269	360,848	216.2
T-1639-A	1,814,681	361,036	220.7
T-1640-A	1,814,906	359,959	227.9
T-1641-A	1,814,690	359,919	225.8
T-1642-A	1,814,453	359,967	225.2
T-1643-A	1,814,473	359,869	224.4
T-1644-A	1,814,926	359,861	226.5
T-1645-A	1,814,616	359,184	225.8
T-1646-A	1,815,049	359,274	227.4
T-1647-A	1,818,668	383,646	186.3
T-1648-A	1,817,662	383,643	183.2
T-1649-A	1,817,763	384,234	183.4
T-1650-A	1,818,198	384,160	186.4
T-1651-A	1,817,872	384,875	182.9
T-1652-A	1,818,299	384,751	184.6
T-1653-A	1,818,417	385,441	179.0
T-1654-A	1,817,981	385,516	176.5
T-1655-A	1,818,518	386,033	178.9
T-1656-A	1,818,082	386,107	178.1
T-1657-A	1,818,183	386,698	175.1
T-1658-A	1,818,210	386,856	157.5
T-1659-A	1,818,619	386,624	179.6
T-1660-A	1,818,720	387,216	179.3
T-1661-A	1,818,809	387,738	156.1
T-1662-A	1,818,502	387,253	159.7
T-1663-A	1,818,401	386,661	177.2
T-1664-A	1,818,300	386,070	177.7
T-1665-A	1,818,199	385,478	171.2
T-1666-A	1,818,081	384,788	184.2
T-1667-A	1,817,980	384,197	185.3
T-1668-A	1,817,880	383,605	185.3
T-1669-A	1,817,795	383,113	182.7
T-1670-A	1,817,711	382,620	172.8
T-1671-A	1,817,106	379,071	186.3
T-1672-A	1,817,005	378,480	188.6
T-1673-A	1,816,702	376,705	197.5
T-1674-A	1,816,500	375,522	216.0
T-1675-A	1,816,298	374,339	192.8
T-1676-A	1,816,197	373,748	195.0
T-1677-A	1,816,096	373,157	201.1
T-1678-A	1,815,995	372,565	200.6
T-1679-A	1,815,894	371,974	202.1
T-1680-A	1,815,798	371,412	201.3
T-1681-A	1,816,016	371,375	203.0
T-1682-A	1,815,692	370,791	187.9
T-1683-A	1,815,591	370,199	192.1
T-1684-A	1,815,809	370,162	199.8
T-1685-A	1,815,700	369,521	200.3
T-1686-A	1,815,482	369,559	189.6
T-1687-A	1,815,407	368,979	197.3
T-1688-A	1,815,385	369,016	197.1
T-1689-A	1,815,314	368,573	197.4
T-1690-A	1,815,096	368,610	197.0
T-1691-A	1,815,263	368,277	197.7
T-1692-A	1,814,579	364,265	215.4
T-1693-A	1,814,540	364,038	217.6
T-1694-A	1,814,377	363,082	219.7
T-1695-A	1,814,309	362,688	216.9
T-1696-A	1,814,302	361,774	214.4
T-1697-A	1,814,424	361,187	215.8
T-1698-A	1,815,465	360,991	216.6
T-1699-A	1,814,955	358,641	226.3
T-1700-A	1,814,739	358,596	226.3
T-1701-A	1,815,078	358,054	226.6
T-1702-A	1,815,294	358,099	227.4
T-1703-A	1,815,200	357,467	228.2
T-1704-A	1,815,323	366,879	229.2
T-1705-A	1,815,445	356,292	228.5

FILE NO. MC-A-2/2
PLATE III - 2

ST LAWRENCE RIVER PROJECT
LONG SAULT CANAL
DRILL HOLES, AUGER BORINGS & HAND PROBINGS
WITH NUMBERS GREATER THAN 1500

Drill Hole No.	Coordinates N	E	Elevation
T-1700-A	1,815,961	350,337	228.9
T-1707-A	1,815,700	356,151	218.7
T-1708-A	1,815,471	356,169	215.8
T-1709-A	1,815,284	355,982	210.7
T-1710-A	1,315,110	358,980	226.5
T-1711-A	1,814,894	358,935	226.2
T-1712-A	1,814,678	358,890	225.5
T-1713-A	1,814,545	359,526	224.1
T-1714-A	1,814,761	359,571	225.8
T-1715-A	1,814,978	359,616	226.9
T-1716-A	1,814,628	360,208	231.5
T-1717-A	1,814,506	363,841	221.1
T-1718-A	1,814,827	367,033	208.8
T-1719-A	1,815,179	367,784	203.1
T-1720-A	1,815,454	368,141	207.1
T-1721-A	1,815,617	371,666	197.9
T-1722-A	1,815,735	372,356	204.8
T-1723-A	1,815,953	372,319	200.5
T-1724-A	1,816,171	372,282	205.4
T-1725-A	1,816,238	372,676	201.9
T-1726-A	1,816,020	372,713	201.2
T-1727-A	1,815,803	372,750	206.6
T-1728-A	1,815,304	373,342	200.2
T-1729-A	1,815,021	374,032	194.9
T-1730-A	1,816,239	373,994	195.7
T-1731-A	1,816,457	373,957	203.1
T-1732-A	1,816,357	374,684	195.4
T-1733-A	1,816,608	374,844	195.6
T-1734-A	1,816,970	376,964	191.9
T-1735-A	1,816,752	377,001	195.5
T-1736-A	1,816,534	377,038	198.9
T-1737-A	1,816,627	377,580	196.3
T-1738-A	1,817,063	377,506	189.6
T-1739-A	1,817,180	378,196	187.2
T-1740-A	1,816,963	378,233	188.6
T-1741-A	1,816,745	378,270	192.0
T-1742-A	1,816,938	379,404	201.6
T-1743-A	1,817,031	379,946	192.6
T-1744-A	1,817,249	379,909	186.7
T-1745-A	1,817,358	380,550	191.8
T-1746-A	1,817,140	380,587	202.9
T-1747-A	1,817,342	381,770	189.6
T-1748-A	1,817,426	382,263	197.8
T-1749-A	1,817,644	382,225	181.2
T-1750-A	1,817,862	382,188	179.0
T-1751-A	1,817,971	382,829	185.8
T-1752-A	1,817,753	382,866	179.5
T-1753-A	1,817,536	382,903	171.9
T-1754-A	1,817,621	383,347	168.5
T-1755-A	1,817,829	383,310	185.0
T-1756-	1,818,047	383,273	186.2
D-1757-	1,813,776	360,205	222.7
D-1758-	1,813,425	357,776	237.8
D-1759	1,812,646	355,224	253.0
D-1760-	1,812,380	354,047	238.6
D-1761-	1,811,791	351,448	223.6
D-1762-	1,811,621	350,701	253.0
D-1763-	1,811,445	349,924	259.5
D-1764-	1,811,091	348,361	228.3
D-1765-	1,810,829	347,206	241.3
D-1766-	1,810,567	346,050	243.6
D-1767-	1,808,538	337,344	225.8
D-1768-	1,808,434	336,505	226.3
D-1769-	1,808,320	335,912	229.7
D 1770-	1,809,688	342,173	226.7
D 1771	1,809,909	343,148	229.4
D 1772	1,810,064	343,831	233.2
D 1773	1,810,241	344,611	232.8
D 1774	1,818,346	381,277	187.9
D 1775	1,818,114	383,402	186.7
D 1776	1,818,149	383,609	186.9
D 1777	1,818,183	383,806	187.0
D 1778	1,818,247	384,182	186.6
D 1779	1,818,275	384,348	186.1
D 1780	1,818,301	384,496	185.4
D 1781	1,818,343	384,742	184.8
D 1782	1,818,372	384,921	184.3
D 1783	1,818,410	385,137	182.3
D 1784	1,817,591	383,492	173.0
D 1785	1,817,627	383,699	181.5
D 1786	1,817,430	383,733	166.2
D 1787	1,817,662	383,906	183.0
D 1788	1,817,694	384,094	183.0
D 1789	1,817,726	384,281	183.0
D 1790	1,817,753	384,439	183.0
D 1791	1,817,778	384,586	182.9
D 1792	1,817,820	384,833	182.7
D 1793	1,817,851	385,010	182.7
D 1794	1,817,225	385,270	171.4
D 1795	1,817,040	385,050	173.9
D 1796	1,817,185	385,810	157.1
D 1797	1,810,870	385,470	170.5
D 1798	Cancelled		Cancelled
D 1799	Cancelled		Cancelled
T-1800-A	1,814,148	360,849	215.5
T-1801-A	1,814,126	360,751	216.0
T-1802-A	1,814,120	360,722	216.8
T-1803-A	1,813,866	360,605	216.2
T-1804-A	1,813,691	360,435	216.1
P 1805	1,813,585	360,069	223.4
P 1806	1,813,800	360,313	223.1
T-1807-A	1,813,971	360,069	223.4

Drill Hole No.	Coordinates N	E	Elevation
T-1808-A	1,813,756	360,117	222.1
T-1809-A	1,813,540	360,166	219.9
T-1810-A	1,813,949	359,971	221.7
T-1811-A	1,813,734	360,020	220.3
T-1812-A	1,813,518	360,069	218.9
T-1813-A	1,813,451	359,776	217.3
T-1814-A	1,813,667	359,727	218.5
T-1815-A	1,813,883	359,679	220.2
T-1816-A	1,813,839	359,483	221.6
T-1817-A	1,813,623	359,532	219.4
T-1818-A	1,813,817	359,386	223.2
T-1819-A	1,813,601	359,435	220.8
T-1820-A	1,813,386	359,484	218.6
T-1821-A	1,813,352	359,337	219.6
T-1822-A	1,813,319	359,191	221.8
T-1823-A	1,813,535	359,142	225.2
T-1824-A	1,813,750	359,093	228.6
P-1825-	1,813,468	358,850	232.5
P 1826	1,813,253	358,898	227.6
P 1827	1,813,402	358,557	231.6
P 1828	1,813,187	358,606	230.2
P 1829	1,813,336	358,264	239.1
P 1830	1,813,120	358,313	236.2
P 1831	1,813,269	357,972	238.8
P 1832	1,813,054	358,021	232.0
P 1833	1,813,203	356,679	236.1
P 1834	1,812,988	357,728	233.6
P 1835	1,813,137	356,387	245.0
P 1836	1,812,921	257,436	245.4
P 1837	1,813,071	356,094	229.5
P 1838	1,813,286	357,045	228.2
P-1839-A	1,813,264	356,948	224.6
T-1840-A	1,813,048	356,997	225.7
T-1841-A	1,812,833	357,046	226.3
T-1842-A	1,813,026	356,899	223.8
T-1843-A	1,812,789	356,850	221.0
T-1844-A	1,813,004	356,802	219.7
T-1845-A	1,813,220	356,753	222.0
T-1846-A	1,812,767	356,753	220.9
T-1847-A	1,812,982	356,704	223.4
T-1848-A	1,813,198	356,655	225.9
P-1849	1,813,153	356,460	230.0
T-1850-A	1,812,938	356,509	228.7
T-1851-A	1,812,722	356,558	225.0
T-1852-A	1,812,656	356,265	227.4
P 1853	1,812,872	356,216	237.3
P 1854	1,813,087	356,168	230.0
P 1855	1,813,021	355,875	237.2
P 1856	1,812,805	355,924	235.3
P 1857	1,812,590	355,973	229.5
P 1858	1,812,954	355,582	249.3
P 1859	1,812,739	355,631	247.0
P 1860	1,812,673	355,339	250.5
P 1861	1,812,457	355,388	247.7
P 1862	1,812,391	355,095	251.5
P 1863	1,812,606	355,046	255.7
P 1864	1,812,540	354,754	251.5
P 1865	1,812,324	354,802	249.0
P 1866	1,812,496	354,559	242.9
P 1867	1,812,689	354,412	243.3
P 1868	1,812,463	354,412	245.8
P 1869	1,812,407	354,168	245.5
P 1870	1,812,623	354,120	240.4
P 1871	1,812,341	353,876	237.0
P 1872	1,812,556	353,827	230.1
P 1873	1,812,275	353,583	231.4
T-1874-A	1,812,445	353,545	226.4
T-1875-A	1,812,490	353,534	211.8
T-1876-A	1,812,325	353,572	223.8
T-1877-A	1,812,253	353,480	[illegible]
P 1878	1,812,106	353,519	[illegible]
P 1879	1,811,993	353,340	[illegible]
T-1880-A	1,812,090	353,317	[illegible]
T-1881-A	1,812,208	353,293	[illegible]
T-1882-A	1,811,960	353,19[illegible]	[illegible]
T-1883-A	1,811,641	351,785	[illegible]
T-1884-A	1,811,836	351,647	[illegible]
T-1885-A	1,812,051	351,599	[illegible]
T-1886-A	1,812,012	351,423	[illegible]
T-1887-A	1,811,572	351,482	[illegible]
T-1888-A	1,811,788	351,438	[illegible]
T-1889-A	1,811,777	351,389	[illegible]
P 1890	1,811,551	351,389	[illegible]
P 1891	1,811,527	351,283	[illegible]
P 1892	1,811,744	351,243	[illegible]
P 1893	1,811,960	351,194	[illegible]
P 1894	1,811,678	350,950	[illegible]
P 1895	1,811,611	350,658	[illegible]
P 1896	1,811,545	350,365	[illegible]
P 1897	1,811,479	350,072	[illegible]
P 1898	1,811,414	349,785	[illegible]
P 1899	1,811,197	349,830	[illegible]
P 1900	1,811,159	349,663	[illegible]
P 1901	1,811,185	348,776	[illegible]
P 1902	1,811,400	348,727	[illegible]
P 1903	1,811,341	348,463	[illegible]
P 1904	1,811,125	348,512	[illegible]
P 1905	1,810,976	348,238	[illegible]
P 1906	1,811,059	348,219	[illegible]
P 1907	1,811,274	348,170	[illegible]
P 1908	1,811,208	347,878	[illegible]
P 1909	1,810,992	347,927	[illegible]
P 1910	1,810,836	347,927	[illegible]

FILE NO. MC-A-2/3
PLATE III-3

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
DRILL HOLES, AUGER BORINGS, & HAND PROBINGS

Drill Hole No.	Coordinates N	E	Elevation
P 1911	1,810,710	347,683	227.6
P 1912	1,810,926	347,634	236.0
P 1913	1,811,142	347,585	243.7
P 1914	1,810,860	347,382	240.4
P 1915	1,810,644	347,390	235.8
P 1916	1,810,578	347,098	232.2
P 1917	1,810,793	347,049	236.1
P 1918	1,810,847	346,832	234.4
T-1919-A	1,810,749	346,854	232.2
T-1920-A	1,810,534	346,903	230.2
T-1921-A	1,810,512	346,805	228.5
T-1922-A	1,810,727	346,756	233.7
P 1923	1,810,802	346,637	237.1
P 1924	1,810,705	346,659	234.3
T-1925-A	1,810,489	346,708	229.6
P 1926	1,810,445	346,513	232.8
P 1927	1,810,660	346,464	239.3
P 1928	1,810,876	346,415	248.0
P 1929	1,810,379	346,220	238.1
P 1930	1,810,594	346,171	243.9
P 1931	1,810,528	345,879	244.0
P 1932	1,810,313	345,928	235.5
P 1933	1,810,246	345,635	231.9
P 1934	1,810,462	345,586	234.7
P 1935	1,810,677	345,537	236.8
T-1936-A	1,810,655	345,440	232.3
T-1937-A	1,810,440	345,489	231.1
T-1938-A	1,810,224	345,538	224.7
T-1939-A	1,810,424	345,420	223.0
T-1940-A	1,810,180	345,342	228.6
T-1941-A	1,810,395	345,294	229.7
T-1942-A	1,810,611	345,245	231.2
T-1943-A	1,810,545	344,952	231.7
T-1944-A	1,810,329	345,001	230.9
T-1945-A	1,810,114	345,050	231.6
T-1946-A	1,810,047	344,757	231.9
T-1947-A	1,810,263	344,708	233.2
T-1948-A	1,810,478	344,660	234.7
T-1949-A	1,810,412	344,367	234.0
T-1950-A	1,810,196	344,416	233.0
T-1951-A	1,809,981	344,465	231.6
T-1952-A	1,809,915	344,172	230.6
T-1953-A	1,810,130	344,123	232.4
T-1954-A	1,810,346	344,074	231.5
T-1955-A	1,810,279	343,782	233.3
T-1956-A	1,810,064	343,831	233.2
T-1957-A	1,809,848	343,880	231.2
T-1958-A	1,809,812	343,580	228.1
T-1959-A	1,809,997	343,538	233.5
T-1960-A	1,810,213	343,489	233.4
T-1961-A	1,810,147	343,197	233.8
T-1962-A	1,809,931	343,246	232.9
T-1963-A	1,809,790	343,278	222.9
T-1964-A	1,809,649	343,002	218.1

Drill Hole No.	Coordinates N	E	Elevation
T-1965-A	1,809,865	342,953	225.9
T-1966-A	1,810,080	342,904	233.5
T-1967-A	1,810,014	342,612	229.7
T-1968-A	1,809,799	342,660	224.6
T-1969-A	1,809,583	342,709	218.2
P 1970	1,809,517	342,417	219.3
P 1971	1,809,732	342,368	225.8
P 1972	1,809,948	342,319	230.4
P 1973	1,809,876	342,002	223.7
P 1974	1,809,681	342,144	226.2
P 1975	1,809,188	339,969	216.4
P 1976	1,809,403	339,915	218.2
P 1977	1,809,336	339,621	217.5
P 1978	1,809,122	339,676	216.9
T-1979-A	1,808,537	338,096	226.6
T-1980-A	1,808,471	337,804	228.1
T-1981-A	1,808,686	337,755	221.2
T-1982-A	1,808,405	337,511	231.9
T-1983-A	1,808,621	337,467	225.5
T-1984-A	1,808,836	337,418	216.5
T-1985-A	1,808,770	337,126	219.0
T-1986-A	1,808,555	337,175	226.3
T-1987-A	1,808,337	337,214	228.6
T-1988-A	1,808,295	337,028	233.0
T-1989-A	1,808,511	336,980	227.9
T-1990-A	1,808,726	336,961	221.2
T-1991-A	1,808,704	336,833	224.3
T-1992-A	1,808,489	336,882	228.7
T-1993-A	1,808,273	336,931	232.9
P 1994	1,808,206	336,633	235.2
P 1995	1,808,421	336,585	231.0
P 1996	1,808,638	336,541	227.1
P 1997	1,808,571	336,248	217.4
T-1998-A	1,808,355	336,292	222.0
T-1999-A	1,808,139	336,341	228.7
D 2000	1,817,010	363,330	210.7
D 2001-	1,816,840	363,252	212.2
D 2002	1,817,090	363,200	221.6
D 2003	1,817,180	363,410	208.9
D 2004	1,816,905	363,500	219.6
D 2005	1,816,195	364,805	215.2
D 2006	1,816,080	365,170	210.0
D 2007	1,815,890	365,335	222.9
D 2008	1,812,828	358,967	216.8
D 2009	1,812,610	359,240	214.9
D 2010	1,812,395	359,530	215.0
D 2011	1,812,160	359,960	214.8
D 2012	1,811,195	351,435	215.9
D 2013	1,811,205	352,455	226.2
D 2014	1,812,300	355,365	219.7
D 2015	1,812,440	357,080	222.8
D 2016	1,816,533	365,535	209.2
D 2017	1,816,865	365,510	211.4
D 2018	1,816,975	365,925	206.8

FILE NO. MC-A-2/4
PLATE III-4

SOUTH CHANNEL

CROIL ISLAND

CROIL ISLAND

BIG SNY

DELANEY ISLAND

RICHARDS POINT

RICHARDS LANDING

STATE HIGHWAY 37B

STA. 43+80 LIMIT OF CONTRACT WORK

E 336,050

N 1,608,200

Center Line of Canal

N77° 13' 40" E

Ice Cribs

Flow

MATCH LINE SHEET NO. 6 STA 113+60

LEGEND

Location of subsurface exploration.

- Probing and Auger Holes
- Drill Hole

T____ Denotes Auger Holes

P____ Denotes Hole probed by hand

NR Denotes bottom elevation of Hole not drilled in Rock.

GENERAL NOTES

Topography traced from Rock Survey Maps.
Contour Interval = 2.5'
Property Lines Shown thus _____
Coordinate System is U.S.C. & G.S. Transverse Mercator projection for New York - East
Elevations conform to U.S.G.S. datum. (M.S.L.)
Location of Explorations obtained by survey.

339,000

TYPE	DATE	REVISION	REVISED BY	CK BY	AP BY

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

PLAN OF BORINGS & PROBINGS

STA. 43 + 80 TO STA. 113 + 60

IN 44 SHEETS | SHEET NO 5 | SCALE 1 IN = 200 FT

200 0 200 400

U. S. ENGINEER OFFICE, MASSENA, NEW YORK FEBRUARY, 1942

SUBMITTED: R. M. Hanna

APPROVED: Brig. Gen. U.S.A. Division Engineer

APPROVED: Col. Corps of Engineers, Chief of Engineers

DRAWING FILED WITH FWA RECORD WPS | FILE NO MC-A-2/5 | TRACING FILED WITH ORIGINAL OR ENDORSEMENT DATED 1941

PLATE III-5

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

LONG SAULT ISLAND

SOUTH CHANNEL

Match Line Sta. 113+60 Sheet No. 5

Match Line Sta. 189+00 Sheet No. 7

Center Line of Canal

N 77°43'-40" E

Submerged Wier

Flow

MASSENA POWER CANAL

COUNTY ROAD

STATE HIGHWAY 37B

LEGEND:
- Drill Holes
- Probe & Auger Holes
- T___o Denotes Auger Hole
- P Denotes Hole probed by hand.
- NR Denotes bottom elevation of Hole not drilled to Rock

GENERAL NOTES
Topography Traced from Rose Survey Maps revised to January 1923. Contour Interval 1-2.5'. Coordinate system is U.S.C.&G.S. Transverse Mercator Projection for New York-East.
Property Lines Shown Thus _____
Elevations conform to U.S.G.S. datum.-(N.S.L., 1912 adj.)
Location of Exploration obtained by Survey.

TYPE	DATE	REVISION	REVD BY	CK. BY	APP BY

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
PLAN OF BORINGS & PROBINGS
STA. 113 + 60 TO STA. 189 + 00

IN 44 SHEETS | SHEET NO 6 | SCALE 1 IN = 200 FT

200 0 200 400

U S ENGINEER OFFICE, MASSENA, NEW YORK FEB., 1942

SUBMITTED P. M. Warner, DISTRICT ENGINEER | APPROVED, CHIEF OF ENGINEERS

DRAWN BY J. A. H. | CHECKED BY W. I. S. | FILE NO MC-A-2/6

PLATE III-6

338.000

LONG SAULT ISLAND

LONG SAULT ISLAND SOUTH CHANNEL

Center Line of Canal

N 77°-19'-40" E

Flow

COUNTY ROAD

COUNTY ROAD

MATCH LINE

MATCH LINE

SHEET NO 6

SHEET NO 8

STA 189+00

STA 265+40

LEGEND.

- Drill Holes since Oct 1940
- Probe & Auger Holes
- Test Pits

T___a Denotes Auger Hole.
P___ Denotes Hole Probed by Hand
PH__ Denotes Hole Probed by Highmark Probing Machine
NR Denotes bottom elevation of Hole not drilled to Rock

NOTE:

Topography Traced from Ross Survey Maps revised to Jan. 1928.
Contour Interval 1-2.5'
Property Lines Shown Thus ——·——
Coördinate System is U.S.C.&G. Transverse Mercator Projection for New York, East.
Elevations conform to U.S.G.S. datum-(M.S.L., 1912 adj.)
Location of Exploration obtained by Survey

TYPE	DATE	REVISION	REVISED BY	AP BY

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

PLAN OF BORINGS & PROBINGS

STA. 189+00 TO STA. 265+40

IN 44 SHEETS | SHEET NO. 7 | SCALE 1 INCH = 200 FT

200 0 200 400

U. S. ENGINEER OFFICE, MASSENA, NEW YORK FEBRUARY 1942

SUBMITTED	RECOMMENDED	APPROVED
W. M. Haines, ENGINEER	Lt. Col. Corps of Engineers, HEAD ENGR	Major General, Chief of Engineers, U.S. Army

DRAWN BY F.H.A. CHECKED BY W.F.S. FILE NO MC-A-2/7

TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 1941

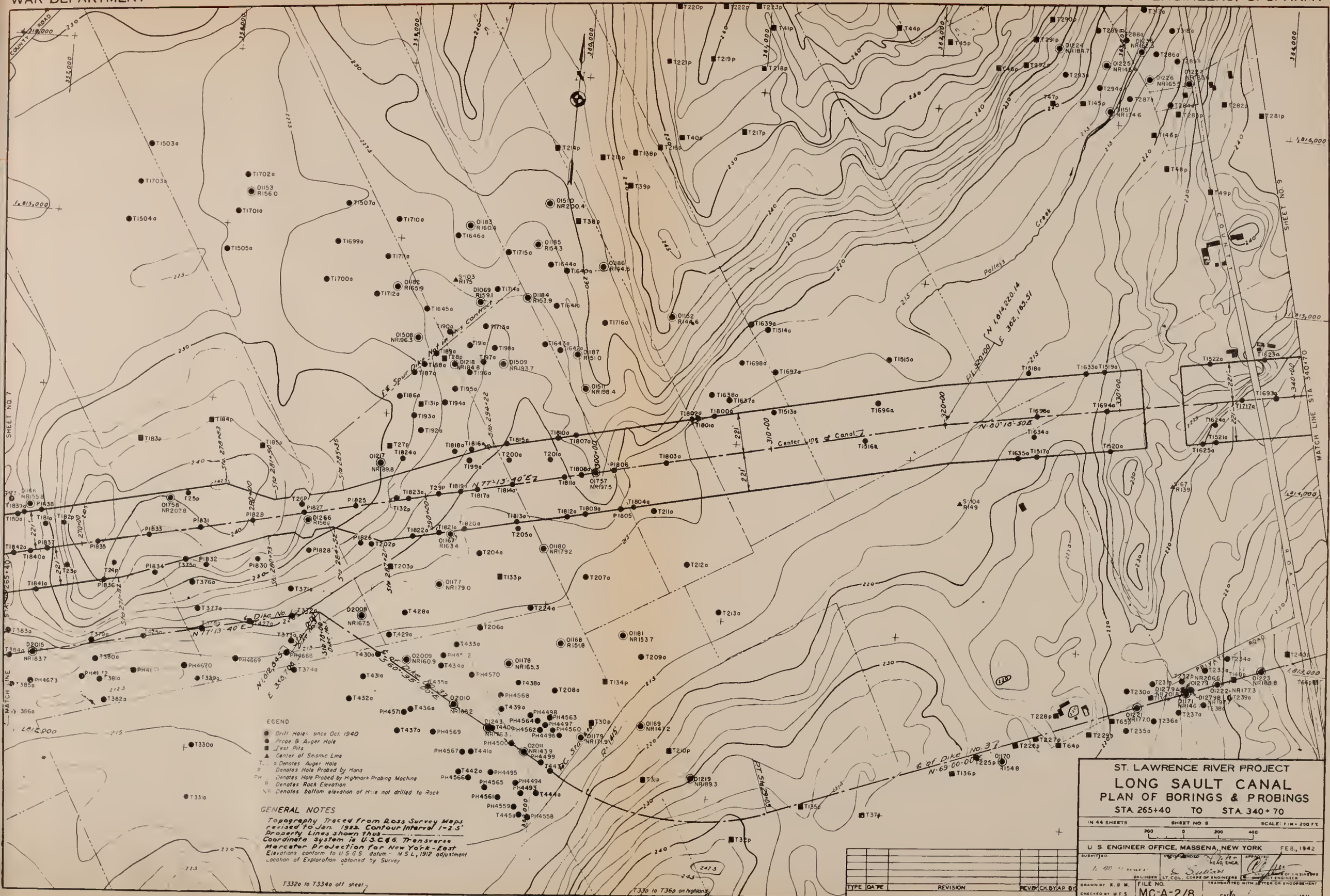

COUNTY ROAD
SHEET NO. 7
SHEET NO. 9
MATCH LINE STA 340+70
MATCH LINE
Pollets Creek
Not in this Contract
Lt Spur Dike
Center Line of Canal Z
Lt of Dike No. 31
Lt of Dike No. 32
PRIVATE ROAD
N 1,614,220.14
E 362,163.51
N 77°-13'-40"E
N 60°-10'-50"E
N 69°-00'-00"E
S 60°-35'-00"E
N 11°-40'-00"E
N 11°-13'-40"E
EGEND
Drill Holes since Oct. 1940
Probe & Auger Hole
Test Pits
Center of Seismic Line
T Denotes Auger Hole
P Denotes Hole Probed by Hand
PH Denotes Hole Probed by Highmark Probing Machine
R Denotes Rock Elevation
NR Denotes bottom elevation of Hole not drilled to Rock
GENERAL NOTES
Topography Traced from Ross Survey Maps revised to Jan. 1923. Contour Interval 1-2.5'
Property Lines shown thus
Coordinate System is U.S.C.&G. Transverse Mercator Projection for New York-East
Elevations conform to U.S.G.S. datum - M.S.L., 1912 adjustment
Location of Exploration obtained by Survey
T3320 to T3340 off sheet
T33p to T36p on highland
ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
PLAN OF BORINGS & PROBINGS
STA. 265+40 TO STA. 340+70
IN 44 SHEETS
SHEET NO 8
SCALE: 1 IN = 200 FT
U. S. ENGINEER OFFICE, MASSENA, NEW YORK FEB., 1942
TYPE DATE REVISION REVIEWED BY AP BY
DRAWN BY R.G.M.
CHECKED BY W.F.S.
FILE NO. MC-A-2/8

PLATE NO. III-8

WAR DEPARTMENT

CORPS OF ENGINEERS, U S ARMY

MATCH LINE FOR SHEET NO. 8

STA. 340+70

MATCH LINE FOR SHEET NO. 10

STA. 412+90

Bottom Width 442'

Center Line of Canal

Power Transmission Lines

Steel Transmission Towers

3 Timber Poles

COUNTY ROAD

Robinson

LEGEND:

- Drill Holes since Oct 1940.
- Probe & Auger Holes
- Center of Survey Line
- Test Pit

T___a Denotes Auger Hole

PH___ Denotes Hole Probed by Highmark Probing Machine

R Denotes Rock Elevation

NR Denotes bottom elevation of Hole not drilled to Rock

● Denotes Drill hole drilled prior to October 1940

GENERAL NOTES:

Topography traced from Ross Survey Maps revised to Jan. 1, 1923 Contour interval 2.5'

Property Lines shown thus ———— ———

Coordinate system is the U.S.C.&G.S. Transverse Mercator Projection for New York, East.

Elevations conform to U.S.C.S. datum - (M.S.L., 1912 adj.).

Location of Exploration obtained by survey

Accuracy of location of drill holes drilled prior to Oct 1940 not known

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

PLAN OF BORINGS & PROBINGS

STA. 340+70 TO STA 412+90

IN 44 SHEETS | SHEET NO. 9 | SCALE 1IN=200FT

U.S. ENGINEER OFFICE, MASSENA, NEW YORK FEBRUARY 1942

SUBMITTED: R.M. Hazen, ENGINEER | RECOMMENDED: K.B. Lange, LT. COL. CORPS OF ENGINEERS | APPROVED: E.S. Sibley, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY K.O.M. | CHECKED BY W.F.S. | FILE NO. MC-A-2/9 | TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 1941

TYPE	DATE	REVISION	REV BY	CK BY	AP BY

PLATE III - 9

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY

ST LAWRENCE RIVER

BARNHART ISLAND MAIN CHANNEL

ROBINSON BAY

1 - T464a	12 - T475a	23 - T486a	34 - T497a
2 - T465a	13 - T476a	24 - T487a	35 - T498a
3 - T466a	14 - T477a	25 - T488a	36 - T499a
4 - T467a	15 - T478a	26 - T489a	37 - T500a
5 - T468a	16 - T479a	27 - T490a	38 - T501a
6 - T469a	17 - T480a	28 - T491a	39 - T502a
7 - T470a	18 - T481a	29 - T492a	40 - T503a
8 - T471a	19 - T482a	30 - T493a	41 - T504a
9 - T472a	20 - T483a	31 - T494a	42 - T505a
10 - T473a	21 - T484a	32 - T495a	43 - T506a
11 - T474a	22 - T485a	33 - T496a	

N 1,817,470
E 371,240

COUNTY ROAD

Dike No 6

N80°19'E

N80°-18-50"E

PI STA. 470+00
N 1,816,744
E. 376,952

N.82°-17-36"E

Bottom Width

E of Canal

MATCH LINE FOR SHEET NO 9

MATCH LINE FOR SHEET NO 11

LEGEND:

- Drill Holes since Oct. 1940.
- Holes drilled prior to Oct. 1940
- Test Pits.
- Center of Seismic Line.
- Test Trench
- R Denotes Rock Elevation.
- NR Denotes bottom Elevation of Hole not drilled to Rock.

GENERAL NOTES

Topography traced from Ross Survey maps revised to Jan 1, 1923. Contour interval = 2.5 ft.
Property lines shown thus.
Coordinate System is U.S.C.&G.S. Transverse Mercator Projection for New York-East
Elevations conform to U.S.G.S. datum.-(M.S.L., 1912 adj.)
Location of Holes drilled since Oct. 1940 obtained by Survey.
Accuracy of Location of Holes drilled prior to Oct. 1940 not known

TYPE	DATE	REVISION	REVISION BY	AP. BY

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

PLAN OF BORINGS & PROBINGS

STA. 412 + 90 TO STA. 485 + 25

IN 44 SHEETS | SHEET NO 10 | SCALE 1 IN. = 200 FT

200 0 100 400

U.S. ENGINEER OFFICE, MASSENA, NEW YORK, JANUARY 31, 1942

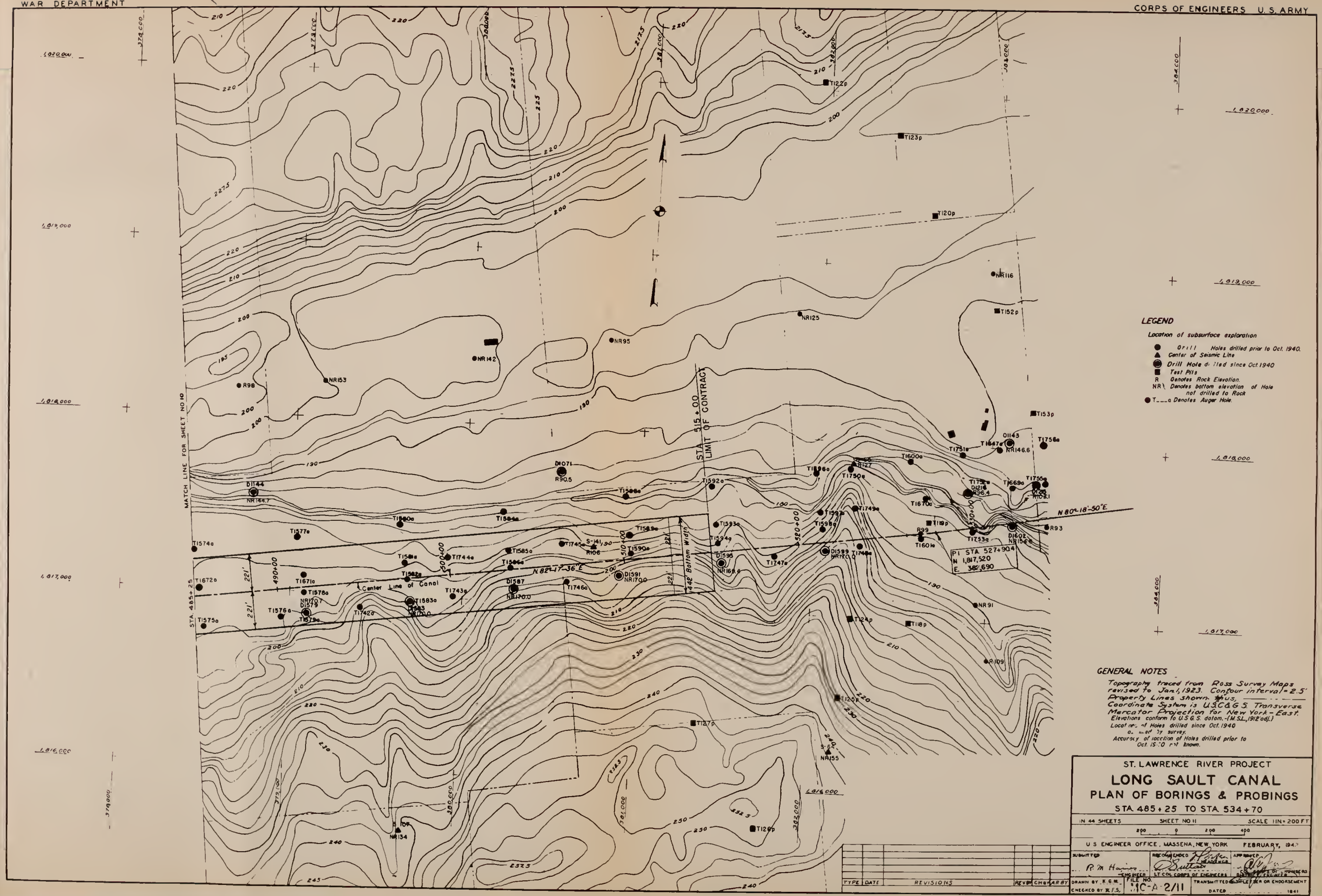
SUBMITTED: A. M. Hunter, ENGINEER

RECOMMENDED: W. W. Wilder, CHIEF, PLAN & ENGR. BR.; Lt. Col. Cokl, CORPS OF ENGINEERS

APPROVED: [illegible], COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY J.A.N. | CHECKED BY W.F.S. | FILE NO. MC-A-2/10 | TRANSMITTED WITH LETTER OF TRANSMITTAL DATED [illegible] 1941

PLATE III - 10



LEGEND

Location of subsurface exploration

- ● Drill Holes drilled prior to Oct. 1940.
- ▲ Center of Seismic Line
- ◉ Drill Hole drilled since Oct 1940
- ■ Test Pits
- R Denotes Rock Elevation.
- NR Denotes bottom elevation of Hole not drilled to Rock
- ●T___a Denotes Auger Hole.

GENERAL NOTES

Topography traced from Ross Survey Maps revised to Jan 1, 1923. Contour interval = 2.5'
Property Lines shown thus _____
Coordinate System is U.S.C.&G.S. Transverse Mercator Projection for New York - East.
Elevations conform to U.S.G.S. datum. - (M.S.L., 1912 adj.)
Location of Holes drilled since Oct. 1940 as staked by survey.
Accuracy of location of Holes drilled prior to Oct. 1940 not known.

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

PLAN OF BORINGS & PROBINGS

STA. 485 + 25 TO STA. 534 + 70

IN 44 SHEETS | SHEET NO 11 | SCALE 1IN = 200 FT

200 0 200 400

U. S. ENGINEER OFFICE, MASSENA, NEW YORK FEBRUARY, 194?

SUBMITTED	RECOMMENDED	APPROVED
P. M. Haines, ENGINEER	LT. COL. CORPS OF ENGINEERS, DISTRICT ENGINEER	COLONEL, CORPS OF ENGINEERS, DIVISION ENGINEER

DRAWN BY K.G.M. | FILE NO. 1C-A-2/11 | TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 1941

TYPE	DATE	REVISIONS	REVD	CHK	ARBY

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

LEGEND

- Drill Holes since Oct 1940
- Drill Holes prior to Oct 1940, Auger Holes & Probe Holes since Oct 1940
- Center of Seismic Line
- Test pits
- R Denotes Rock Elevation
- NR Denotes bottom elevation of Hole not drilled to Rock
- PH Denotes hole probed by Highmark Probing Machine — T____ Denotes Auger Holes

NOTE:

Elevations conform to U.S.G.S. datum - (M.S.L., 1912 adj.)
Location of Holes drilled since Oct 1940 obtained by survey
Accuracy of location of Holes drilled prior to Oct 1940 not known

ST. LAWRENCE RIVER PROJECT

GRASS RIVER LOCK

PLAN OF EXPLORATION & ROCK CONTOURS

SHEETS	SHEET NO	SCALE
		200 0 400

U. S. ENGINEER OFFICE, MASSENA, NEW YORK

SUBMITTED:	RECOMMENDED:	APPROVED:
ENGINEER	U.S. CORPS OF ENGINEERS	COL. CORPS OF ENGINEERS DISTRICT ENGINEER

DRAWN BY JEY | CHECKED BY RCK | FILE NO. MC-A-2/109 | TRANSMITTED WITH LETTER OF ENGINEER DATED JAN. 31, 1942

PLATE III-12

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S.ARMY

GENERAL NOTES:

Topography traced from Ross Survey Maps revised to Jan 1, 1923. Contour interval-2.5'
Property Lines shown thus ——— . ———
Coordinate System is U.S.C.&G.S. Transverse Mercator Projection for New York-East
Exploration to conform to U.S.G.S. Datum.
Location of Exploration obtained by Survey

SHEET NO. 36
SHEET NO. 37
MATCH LINE
MATCH LINE FOR SHEET NO. 37
20'-Contour Limit of Work Area
DIKE NO. 5
N 86° 00' E
Top El 208.0
Limit of Work Area
N 1,812,820
E 373,080
N 1,812,960
E 373,330
T85p
T86p
T87p
T88p
T89p
T90p
T155p
T156p
T157p
T158o
T159o
COUNTY ROAD

LEGEND
Auger Holes
Test Pits

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

PLAN OF EXPLORATION

DIKE NO. 5

IN 44 SHEETS | SHEET NO 39 | SCALE 1 IN = 200 FT

200 0 200 400

U S ENGINEER OFFICE, MASSENA, NEW YORK FEBRUARY, 1942

SUBMITTED | RECOMMENDED | APPROVED

ENGINEER | LT COL., CORPS OF ENGINEERS | COL., CORPS OF ENGINEERS
DIST. ENGINEER

DRAWN BY J.A.H. CHECKED BY G.F.M.

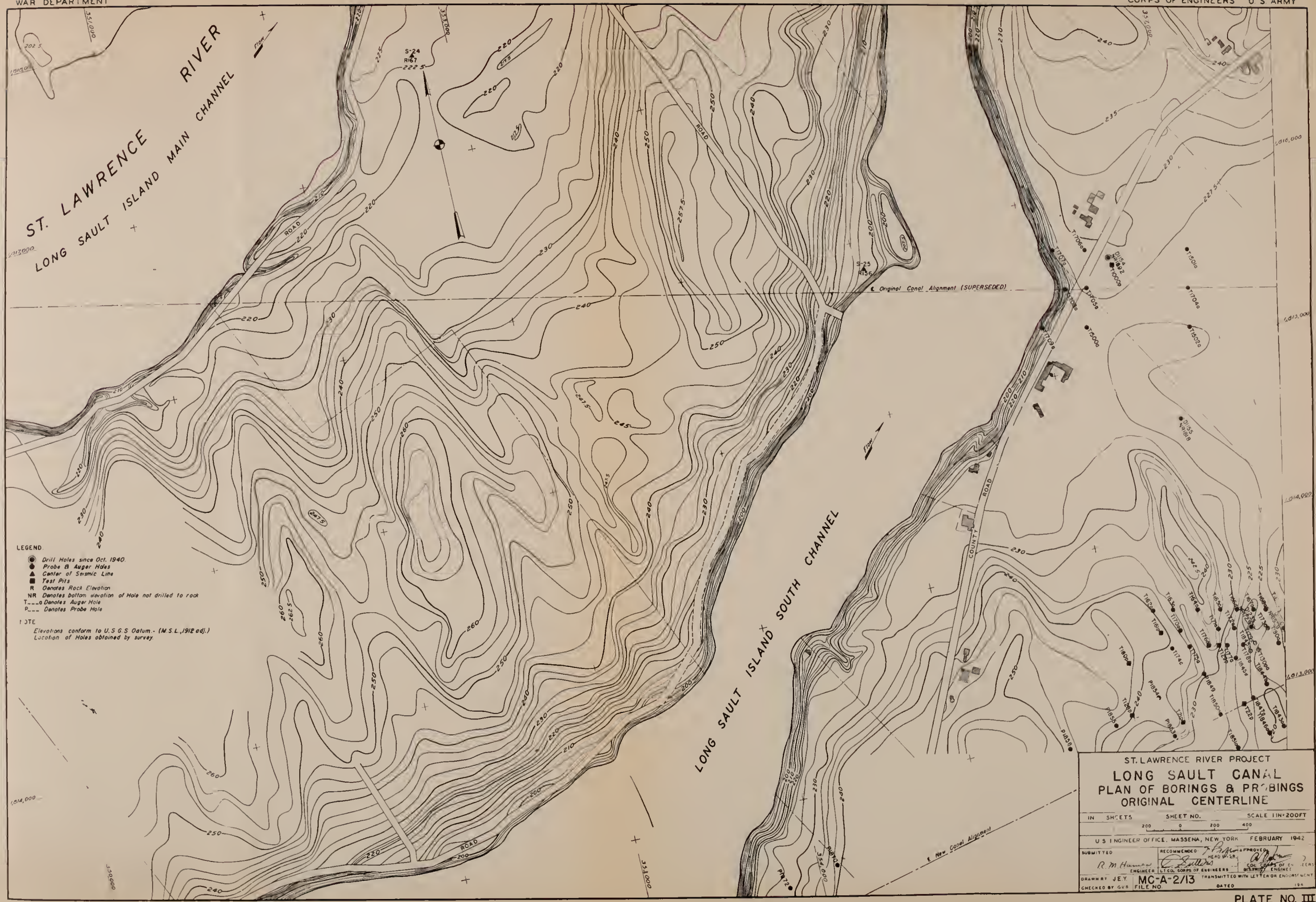
FILE NO. MC-A-2/12

TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 194

PLATE-III-13

WAR DEPARTMENT

CORPS OF ENGINEERS U.S. ARMY



ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL
PLAN OF BORINGS & PROBINGS
ORIGINAL CENTERLINE

IN SHEETS | SHEET NO. | SCALE 1 IN = 200 FT

200 0 200 400

U.S. ENGINEER OFFICE, MASSENA, NEW YORK FEBRUARY 1942

SUBMITTED R.M. Hamer ENGINEER

RECOMMENDED [illegible] HEAD OF DIV.

APPROVED [illegible] COL. CORPS OF ENGINEERS DISTRICT ENGINEER

LT. COL. CORPS OF ENGINEERS

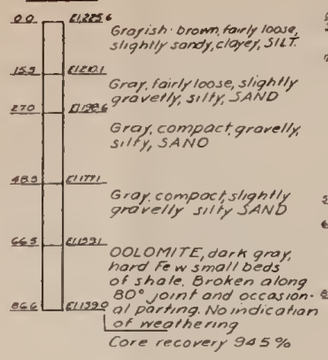
DRAWN BY J.E.Y. CHECKED BY G.V.B.

MC-A-2/13 FILE NO.

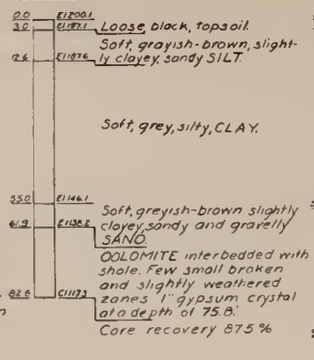
TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 194

PLATE NO. III-14

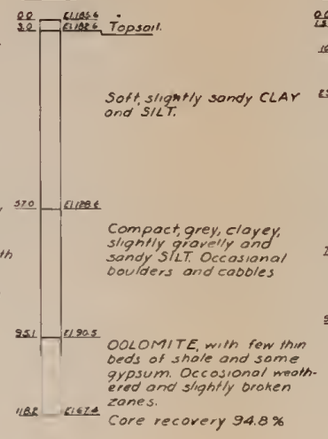
D-1069


0.0 El.1225.6
Grayish-brown, fairly loose, slightly sandy, clayey, SILT.
15.9 El.1210.1
Gray, fairly loose, slightly gravelly, silty, SAND
27.0 El.1198.6
Gray, compact, gravelly, silty, SAND
48.9 El.1177.1
Gray, compact, slightly gravelly silty SAND
66.9 El.1159.1
DOLOMITE, dark gray, hard Few small beds of shale. Broken along 80° joint and occasional parting. No indication of weathering
86.6 El.1139.0
Core recovery 94.5%

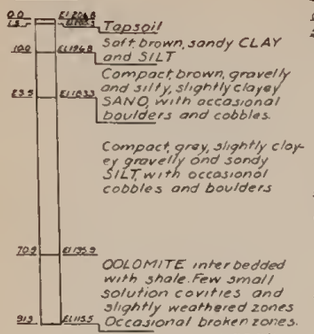
D-1070


0.0 El.1200.1
3.0 El.1197.1
Loose, black, topsoil.
Soft, grayish-brown, slightly clayey, sandy SILT.
12.6 El.1187.6
Soft, grey, silty, CLAY.
55.0 El.1146.1
61.9 El.1138.2
Soft, greyish-brown slightly clayey, sandy and gravelly SAND.
DOLOMITE interbedded with shale. Few small broken and slightly weathered zones 1" gypsum crystal at a depth of 75.8'.
82.6 El.1117.3
Core recovery 87.5%

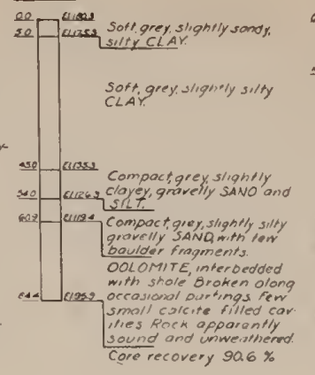
D-1071


0.0 El.1185.6
2.0 El.1183.6
Topsoil.
Soft, slightly sandy CLAY and SILT.
37.0 El.1148.6
Compact, grey, clayey, slightly gravelly and sandy SILT. Occasional boulders and cobbles
95.1 El.1090.5
DOLOMITE, with few thin beds of shale and some gypsum. Occasional weathered and slightly broken zones.
118.2 El.1067.4
Core recovery 94.8%

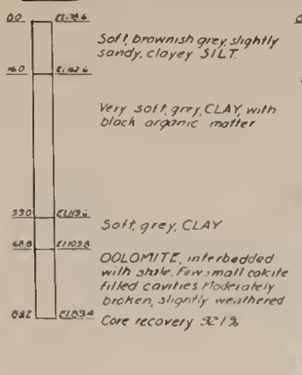
D-1124


0.0 El.1208.8
0.8 El.1207.8
Topsoil
10.0 El.1198.8
Soft, brown, sandy CLAY and SILT
23.9 El.1184.9
Compact, brown, gravelly and silty, slightly clayey SAND with occasional boulders and cobbles.
Compact, grey, slightly clayey gravelly and sandy SILT with occasional cobbles and boulders
70.9 El.1139.9
DOLOMITE interbedded with shale. Few small solution cavities and slightly weathered zones
91.3 El.1119.5
Occasional broken zones.
Core recovery 95.5%

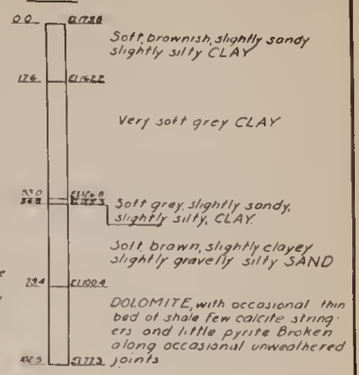
D-1125


0.0 El.1183.3
2.0 El.1163.3
Soft, grey, slightly sandy, silty CLAY.
Soft, grey, slightly silty CLAY.
43.0 El.1135.3
Compact, grey, slightly clayey, gravelly SAND and SILT.
54.0 El.1124.3
60.7 El.1117.4
Compact, grey, slightly silty gravelly SAND with few boulder fragments.
DOLOMITE, interbedded with shale Broken along occasional partings Few small calcite filled cavities Rock apparently sound and unweathered.
84.4 El.1093.9
Core recovery 90.6%

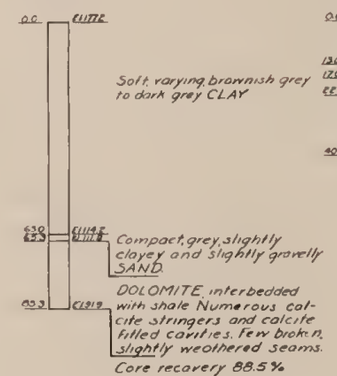
D-1126


0.0 El.1186.6
Soft, brownish grey, slightly sandy, clayey SILT.
14.0 El.1172.6
Very soft grey, CLAY, with black organic matter
33.0 El.1153.6
Soft, grey, CLAY
68.8 El.1118.8
DOLOMITE, interbedded with shale. Few small calcite filled cavities Moderately broken, slightly weathered
84.2 El.1103.4
Core recovery 92.1%

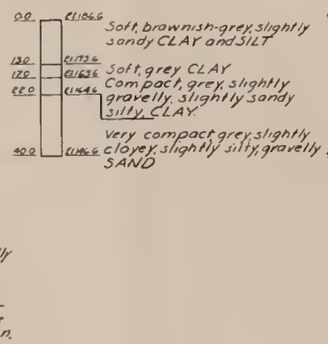
D-1141


0.0 El.1172.8
Soft, brownish, slightly sandy slightly silty CLAY
17.6 El.1155.2
Very soft grey CLAY
33.0 El.1139.8
33.8 El.1139.0
Soft grey, slightly sandy, slightly silty, CLAY.
Soft brown, slightly clayey slightly gravelly silty SAND
73.4 El.1099.4
DOLOMITE, with occasional thin bed of shale few calcite stringers and little pyrite Broken along occasional unweathered joints
83.3 El.1089.3
Core recovery 88%

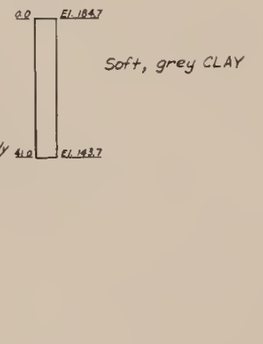
D-1142


0.0 El.1177.5
Soft, varying, brownish grey to dark grey CLAY
63.0 El.1114.5
68.5 El.1109.0
Compact, grey, slightly clayey and slightly gravelly SAND.
DOLOMITE, interbedded with shale Numerous calcite stringers and calcite filled cavities. Few broken, slightly weathered seams.
93.3 El.1084.5
Core recovery 88.5%

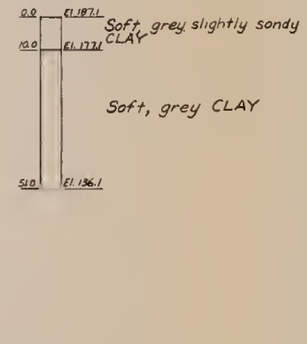
D-1143


0.0 El.1186.6
Soft, brownish-grey, slightly sandy CLAY and SILT
13.0 El.1173.6
17.0 El.1169.6
Soft, grey CLAY
28.0 El.1146.6
Compact, grey, slightly gravelly, slightly sandy silty CLAY
40.0 El.1134.6
Very compact grey, slightly clayey, slightly silty, gravelly SAND

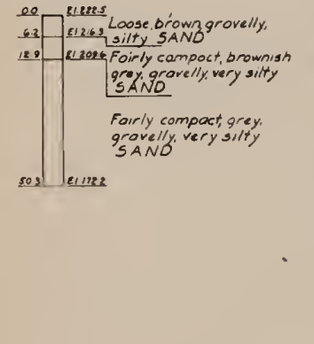
D-1144



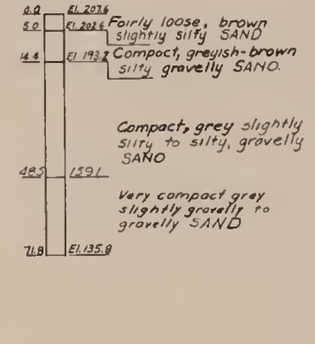
D-1145



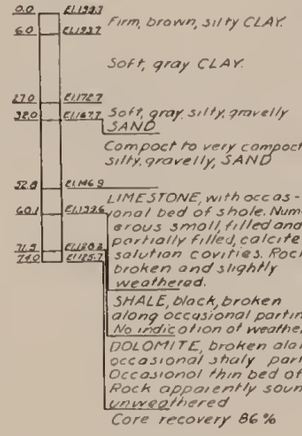
D-1146


0.0 El. 1222.5
6.3 El. 1216.3
Loose, brown gravelly, silty SAND
18.9 El. 1203.4
Fairly compact, brownish grey, gravelly, very silty SAND
Fairly compact, grey, gravelly, very silty SAND
50.3 El. 1172.2

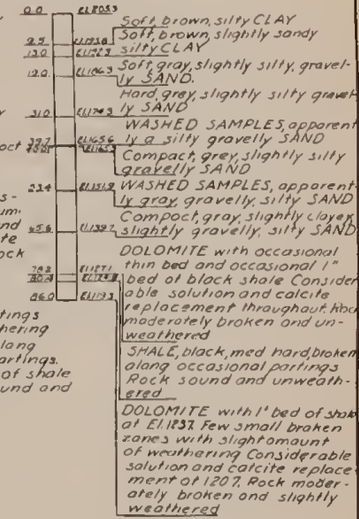
D-1147


0.0 El. 2076
5.0 El. 2026
Fairly loose, brown slightly silty SAND
14.4 El. 1932
Compact, greyish-brown silty gravelly SAND.
Compact, grey slightly silty to silty, gravelly SAND
48.5 1591
Very compact grey slightly gravelly to gravelly SAND
71.8 El. 1135.8

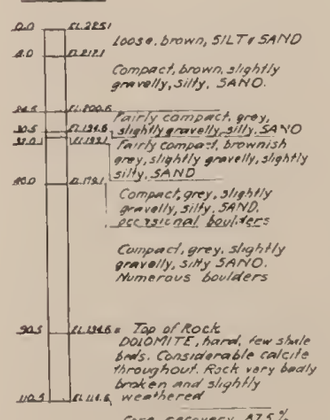
D-1148


0.0 El. 1193.3
Firm, brown, silty CLAY.
6.0 El. 1193.7
Soft, gray CLAY.
27.0 El. 1172.7
38.0 El. 1161.7
Soft, gray, silty, gravelly SAND
Compact to very compact silty, gravelly, SAND
52.0 El. 1146.9
LIMESTONE, with occasional bed of shale. Numerous small, filled and partially filled, calcite solution cavities. Rock broken and slightly weathered.
60.1 El. 1138.6
71.2 El. 1128.2
74.0 El. 1125.7
SHALE, black, broken along occasional partings No indication of weathering
DOLOMITE, broken along occasional shaly partings. Occasional thin bed of shale Rock apparently sound and unweathered
Core recovery 86%

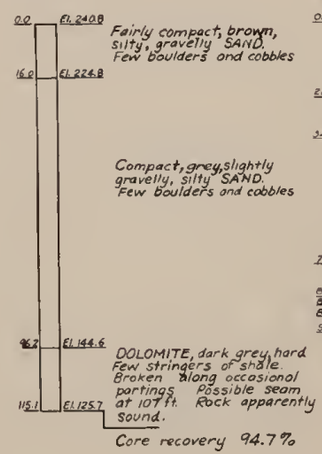
D-1149


0.0 El. 1205.3
Soft, brown, silty CLAY
2.5 El. 1203.8
Soft, brown, slightly sandy silty CLAY
13.0 El. 1192.3
Soft, gray, slightly silty, gravelly SAND.
25.0 El. 1180.3
Hard, grey, slightly silty gravelly SAND
31.0 El. 1174.3
WASHED SAMPLES, apparently a silty gravelly SAND
39.7 El. 1165.6
Compact, grey, slightly silty gravelly SAND
23.4 El. 1151.2
WASHED SAMPLES, apparently gray, gravelly, silty SAND
45.6 El. 1139.7
Compact, gray, slightly clayey, slightly gravelly, silty SAND
DOLOMITE with occasional thin bed and occasional 1" bed of black shale Considerable solution and calcite replacement throughout Rock moderately broken and unweathered
76.2 El. 1108.7
80.4 El. 1104.5
SHALE, black, med hard, broken along occasional partings Rock sound and unweathered
86.0 El. 1099.1
DOLOMITE with 1" bed of shale at El. 1123.7 Few small broken zones with slight amount of weathering Considerable solution and calcite replacement at 1120.7 Rock moderately broken and slightly weathered
Core recovery 94%.

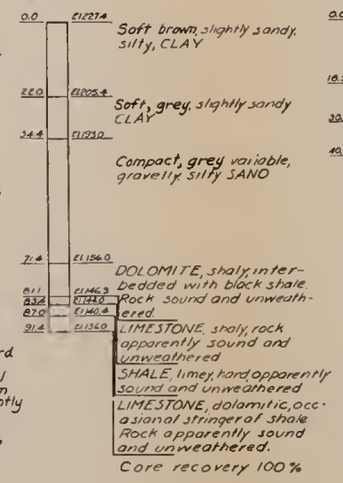
D-1150


0.0 El. 1215.1
Loose, brown, SILT & SAND
4.0 El. 1211.1
Compact, brown, slightly gravelly, silty, SAND.
14.5 El. 1200.6
Fairly compact, grey, slightly gravelly, silty SAND
20.5 El. 1194.6
27.0 El. 1188.1
Fairly compact, brownish grey, slightly gravelly, slightly silty, SAND
Compact, grey, slightly gravelly, silty, SAND, occasional boulders
Compact, grey, slightly gravelly, silty SAND. Numerous boulders
90.5 El. 1124.6
Top of Rock DOLOMITE, hard, few shale beds. Considerable calcite throughout. Rock very badly broken and slightly
110.5 El. 1104.6
weathered
Core recovery 87.5%

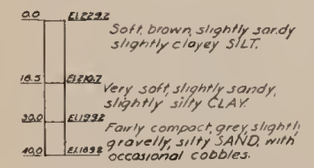
D-1152


0.0 El. 240.8
Fairly compact, brown, silty, gravelly SAND. Few boulders and cobbles
16.0 El. 224.8
Compact, grey, slightly gravelly, silty SAND. Few boulders and cobbles
96.7 El. 144.6
DOLOMITE, dark grey, hard Few stringers of shale. Broken along occasional partings Possible seam at 107 ft. Rock apparently sound.
115.1 El. 125.7
Core recovery 94.7%

D-1153


0.0 El. 227.4
Soft brown, slightly sandy, silty, CLAY
22.0 El. 205.4
Soft, grey, slightly sandy CLAY
34.4 El. 193.0
Compact, grey variable, gravelly, silty SAND
71.4 El. 156.0
DOLOMITE, shaly, interbedded with black shale.
81.1 El. 146.3
83.2 El. 144.2
Rock sound and unweathered
87.0 El. 140.4
91.4 El. 136.0
LIMESTONE, shaly, rock apparently sound and unweathered
SHALE, limey, hard, apparently sound and unweathered
LIMESTONE, dolomitic, occasional stringer of shale Rock apparently sound and unweathered.
Core recovery 100%

D-1154


0.0 El. 229.2
Soft, brown, slightly sandy slightly clayey SILT.
18.3 El. 210.7
Very soft, slightly sandy, slightly silty CLAY.
32.0 El. 193.2
Fairly compact, grey, slightly gravelly, silty SAND, with occasional cobbles.
40.0 El. 185.2

DESCRIPTIVE TERMS

Slightly silty, etc. denotes approximately 1% to 20% by dry weight of silt, etc.

Silty, etc., denotes approximately 20% to 40% by dry weight of silt, etc.

Silt and sand, etc., denotes approximately 40% to 60% by dry weight of silt etc. except and clay denotes more than 30% by dry weight of clay

NOTES

Analyses of overburden are based on dry samples
Analyses of rock are based on 2½ cores obtained by drilling.

Holes numbered 1033 thru 01500 drilled with 3½" casing.

Elevations of holes based on U.S.G.S. datum of '52, 1912 adj.

See sheet File no. MCA-3/1 for coordinates of holes.

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION EXPLORATION NO. 1

IN SHEETS; SHEET NO. 1 SCALE: 1"=20'

FEBRUARY 1942

U.S. ENGINEER OFFICE, MASSENA, N.Y.

SUBMITTED: R. M. Hanna, ENGINEER

RECOMMENDED: [signature], DISTRICT ENGINEER; [signature], LT. COL. CORPS OF ENGINEERS

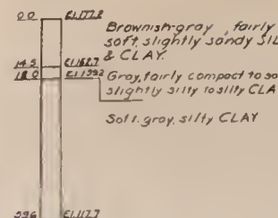
APPROVED: [signature], COLONEL, CORPS OF ENGINEERS, DIVISION ENGINEER

DRAWN BY: F.H.A. CHECKED BY: J.W.

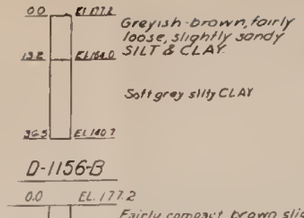
MC-A-2/14 FILE NO.

TRANSMITTED WITH LETTER OR ENDORSEMENT DATED ____ 194

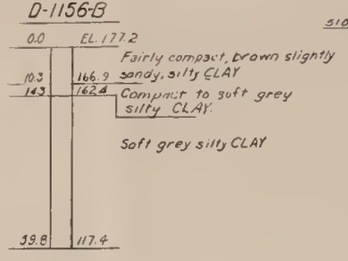
D-1156


0.0 EL 177.2
Brownish-gray, fairly soft, slightly sandy SILT & CLAY.
14.5 EL 162.7
18.0 EL 159.2
Gray, fairly compact to soft, slightly silty to silty CLAY
Soft gray silty CLAY
23.6 EL 153.7

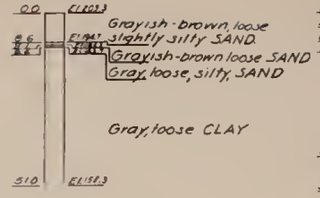
D-1156A



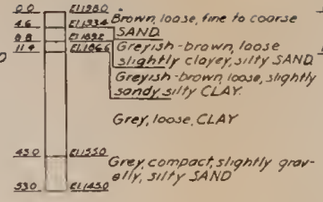
D-1156-B



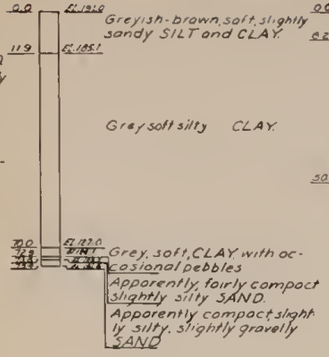
D-1157



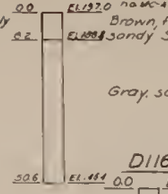
D-1158



D-1160


0.0 EL 129.6
Greyish-brown, soft, slightly
sandy SILT and CLAY.
11.9 EL 117.7
Gray soft silty CLAY.
70.0 EL 59.6
Grey, soft, CLAY with occasional pebbles
Apparently, fairly compact slightly silty SAND.
Apparently compact slightly silty, slightly gravelly SAND

D-1160-A



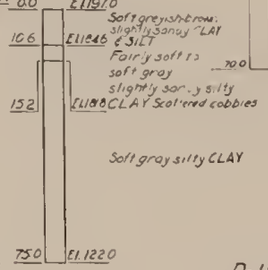
D1166

See sheet file no. MC-A-2/38

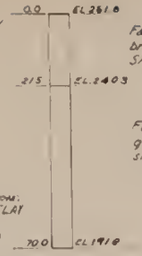
D1167

See below

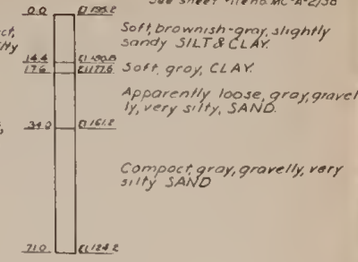
D1160B


0.0 EL 197.0
Soft greyish-brown, slightly sandy CLAY
10.6 EL 186.4 & SILT
Fairly soft to soft gray slightly sandy silty
15.2 EL 181.8 CLAY Scattered cobbles
Soft gray silty CLAY
75.0 EL 122.0

D-1173


0.0 EL 261.0
Fairly compact to compact, brown slightly gravelly, silty SAND.
21.5 EL 240.3
Fairly loose to compact, grey, slightly gravelly, silty SAND.
70.0 EL 191.0

D-1174


0.0 EL 156.2
Soft, brownish-gray, slightly sandy SILT & CLAY.
14.4 EL 141.8
17.6 EL 137.6 Soft, gray, CLAY.
Apparently loose, gray, gravelly, very silty, SAND.
34.9 EL 116.1
Compact, gray, gravelly, very silty SAND
71.0 EL 79.8

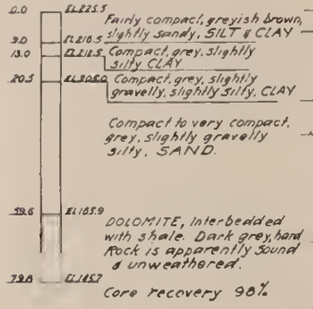
D-1177

See sheet file no. MC-A-2/38

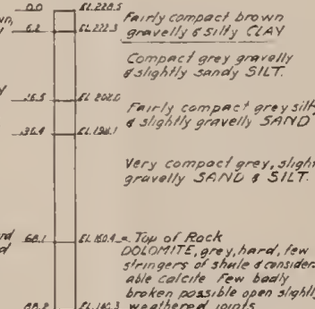
D-1180

0.0 EL 156.2
Soft, brownish-gray, slightly sandy SILT & CLAY.
14.4 EL 141.8
17.6 EL 137.6 Soft, gray, CLAY.
Apparently loose, gray, gravelly, very silty, SAND.
34.9 EL 116.1
Compact, gray, gravelly, very silty SAND
71.0 EL 79.8

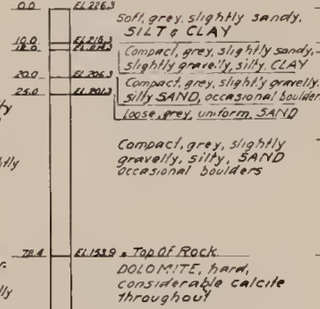
D-1182


0.0 EL 225.5
Fairly compact, greyish brown, slightly sandy, SILT & CLAY
9.0 EL 216.5
13.0 EL 212.5 Compact, grey, slightly silty CLAY
20.5 EL 205.0 Compact, grey, slightly gravelly, slightly silty, CLAY
Compact to very compact, grey, slightly gravelly silty, SAND.
53.6 EL 152.9
DOLOMITE, interbedded with shale. Dark grey, hard Rock is apparently sound & unweathered.
73.8 EL 145.7
Core recovery 98%

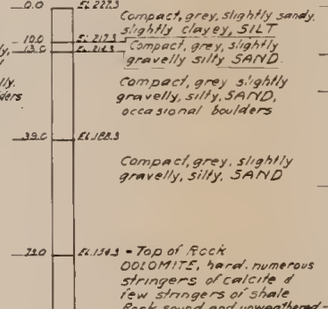
D-1183


0.0 EL 220.5
Fairly compact brown
6.2 EL 222.3 gravelly & silty CLAY
Compact grey gravelly & slightly sandy SILT.
15.5 EL 202.0
Fairly compact grey silty & slightly gravelly SAND
36.4 EL 181.1
Very compact grey, slightly gravelly SAND & SILT.
60.1 EL 160.4 = Top of Rock
DOLOMITE, grey, hard, few stringers of shale & considerable calcite few badly broken possible open slightly weathered joints
68.2 EL 152.3
Core recovery 97%

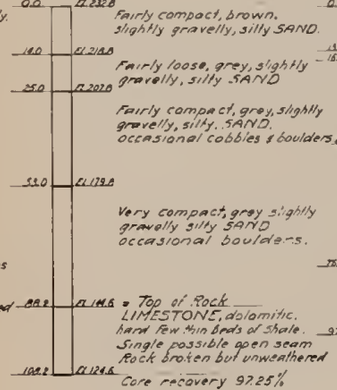
D-1184


0.0 EL 226.3
Soft, grey, slightly sandy, SILT & CLAY
10.0 EL 216.3
11.0 EL 215.3 Compact, grey, slightly sandy, slightly gravelly, silty CLAY
20.0 EL 206.3 Compact, grey, slightly gravelly, silty SAND, occasional boulders
25.0 EL 201.3 Loose, grey, uniform, SAND
Compact, grey, slightly gravelly, silty, SAND occasional boulders
78.4 EL 152.9 = Top of Rock
DOLOMITE, hard, considerable calcite throughout
92.4 EL 133.9
Core recovery 94%

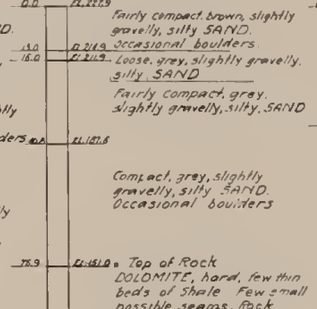
D-1185


0.0 EL 222.3
Compact, grey, slightly sandy, slightly clayey, SILT
10.0 EL 212.3
13.0 EL 209.3 Compact, grey, slightly gravelly silty SAND.
Compact, grey slightly gravelly, silty, SAND, occasional boulders
39.0 EL 183.3
Compact, grey, slightly gravelly, silty, SAND
73.0 EL 149.3 = Top of Rock
DOLOMITE, hard, numerous stringers of calcite & few stringers of shale Rock sound and unweathered
93.2 EL 129.1
Core recovery 95.5%

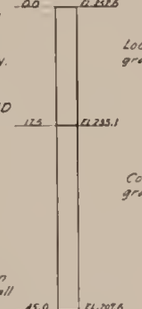
D-1186


0.0 EL 232.8
Fairly compact, brown, slightly gravelly, silty SAND.
16.0 EL 216.8
Fairly loose, grey, slightly gravelly, silty SAND
25.0 EL 207.8
Fairly compact, grey, slightly gravelly, silty SAND, occasional cobbles & boulders
53.0 EL 179.8
Very compact, grey slightly gravelly silty SAND occasional boulders.
88.2 EL 144.6 = Top of Rock
LIMESTONE, dolomitic, hard few thin beds of shale. Single possible open seam Rock broken but unweathered
100.2 EL 124.6
Core recovery 97.25%

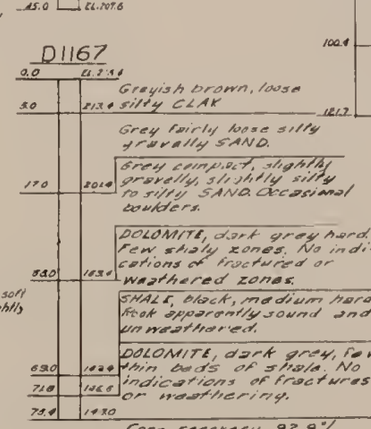
D-1187


0.0 EL 227.9
Fairly compact, brown, slightly gravelly, silty SAND.
13.0 EL 214.9 occasional boulders.
16.0 EL 211.9 Loose, grey, slightly gravelly, silty SAND
Fairly compact, grey, slightly gravelly, silty, SAND
40.8 EL 187.1
Compact, grey, slightly gravelly, silty SAND. Occasional boulders
75.9 EL 152.0 = Top of Rock
DOLOMITE, hard, few thin beds of Shale Few small possible seams. Rock broken, but unweathered
97.0 EL 130.9
Core recovery 95.5%

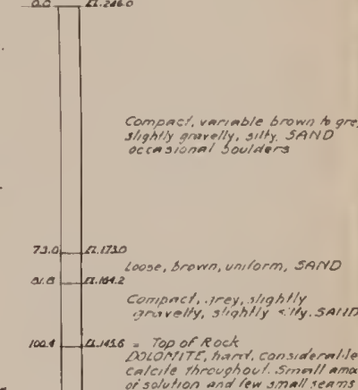
D-1188



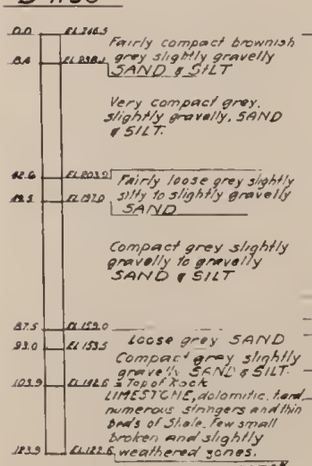
D1167


0.0 EL 171.6
Greyish brown, loose
3.0 EL 168.6 silty CLAY
Grey fairly loose silty gravelly SAND.
17.0 EL 154.6
Grey compact, slightly gravelly, slightly silty to silty SAND. Occasional boulders.
DOLOMITE, dark grey hard. few shaly zones. No indications of fractured or
58.0 EL 113.6 weathered zones.
SHALE, black, medium hard. Rock apparently sound and unweathered.
DOLOMITE, dark grey, few thin beds of shale. No
69.0 EL 102.6 indications of fractures
71.0 EL 100.6 or weathering.
74.0 EL 97.6
Core recovery 92.9%

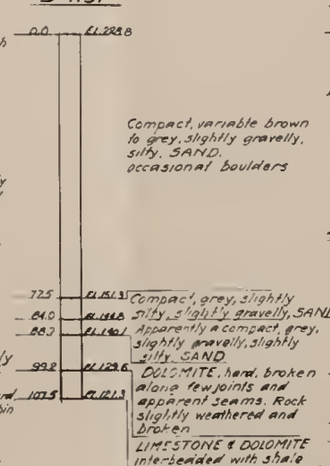
D-1189


0.0 EL 246.0
Compact, variable brown to grey, slightly gravelly, silty, SAND occasional boulders
73.0 EL 173.0
Loose, brown, uniform, SAND
81.8 EL 164.2
Compact, grey, slightly gravelly, slightly silty SAND.
100.4 EL 145.6 = Top of Rock
DOLOMITE, hard, considerable calcite throughout. Small amount of solution and few small seams Rock slightly weathered
121.7 EL 124.3 along seams
Core recovery 89.6%

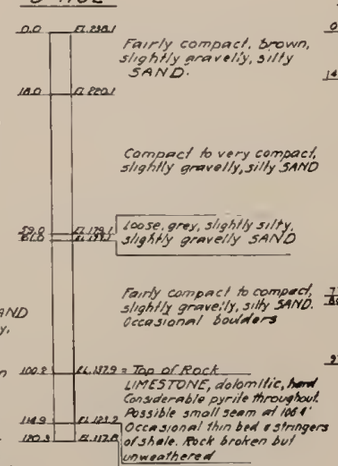
D-1190


0.0 EL 316.3
Fairly compact brownish grey slightly gravelly SAND & SILT
8.4 EL 238.1
Very compact grey, slightly gravelly, SAND & SILT.
42.6 EL 203.9
Fairly loose grey slightly silty to slightly gravelly SAND
48.5 EL 197.0
Compact grey slightly gravelly to gravelly SAND & SILT
87.5 EL 158.0
Loose grey SAND
93.0 EL 153.5
Compact grey slightly gravelly SAND & SILT.
103.9 EL 142.6 = Top of Rock
LIMESTONE, dolomitic, hard numerous stringers and thin beds of Shale. Few small broken and slightly weathered zones.
133.9 EL 112.6
Core recovery 90.75%

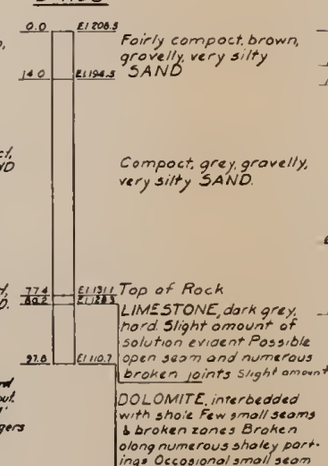
D-1191


0.0 EL 288.8
Compact, variable brown to grey, slightly gravelly, silty, SAND. occasional boulders
72.5 EL 151.3
Compact, grey, slightly
84.0 EL 140.8 silty, slightly gravelly, SAND
88.7 EL 136.1 Apparently a compact, grey, slightly gravelly, slightly silty SAND
99.2 EL 125.6
DOLOMITE, hard, broken along few joints and apparent seams. Rock slightly weathered and broken
103.5 EL 121.3
LIMESTONE & DOLOMITE interbedded with shale Rock slightly weathered along few seams Rock broken
Core recovery 88%

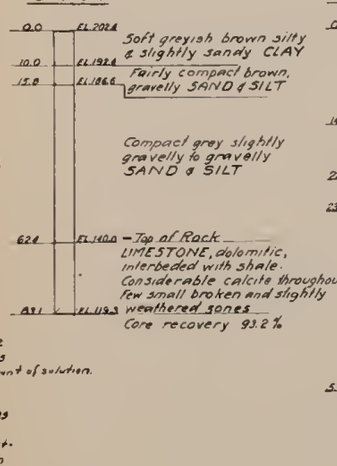
D-1192


0.0 EL 238.1
Fairly compact, brown, slightly gravelly, silty SAND.
18.0 EL 220.1
Compact to very compact, slightly gravelly, silty SAND
Loose, grey, slightly silty, slightly gravelly SAND
Fairly compact to compact, slightly gravelly, silty SAND. Occasional boulders
100.2 EL 137.9 = Top of Rock
LIMESTONE, dolomitic, hard Considerable pyrite throughout. Possible small seam at 106.4' Occasional thin bed & stringers of shale. Rock broken but unweathered
114.9 EL 121.2
120.3 EL 117.8
DOLOMITE, hard, dk. grey, Rock broken but unweathered
Core recovery 85.5%

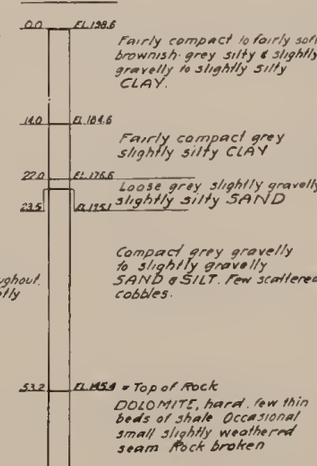
D-1193


0.0 EL 208.9
Fairly compact, brown, gravelly, very silty SAND
14.0 EL 194.9
Compact, grey, gravelly, very silty SAND.
77.4 EL 131.1 Top of Rock
80.2 EL 128.3
LIMESTONE, dark grey, hard. Slight amount of solution evident Possible open seam and numerous broken joints Slight amount of solution.
92.0 EL 116.7
DOLOMITE, interbedded with shale Few small seams & broken zones Broken along numerous shaley partings Occasional small seam Rock broken & slightly weathered along joints.
Core Recovery 85.9%

D-1194


0.0 EL 202.8
Soft greyish brown silty & slightly sandy CLAY
10.0 EL 192.8
15.8 EL 186.6 Fairly compact brown, gravelly SAND & SILT
Compact grey slightly gravelly to gravelly SAND & SILT
62.4 EL 140.0 Top of Rock
LIMESTONE, dolomitic, interbedded with shale. Considerable calcite throughout. Few small broken and slightly
83.1 EL 119.3 weathered zones
Core recovery 93.2%

D-1195


0.0 EL 198.6
Fairly compact to fairly soft brownish grey silty & slightly gravelly to slightly silty CLAY.
14.0 EL 184.6
Fairly compact grey slightly silty CLAY
22.0 EL 176.6
Loose grey slightly gravelly, slightly silty SAND
23.5 EL 175.1
Compact grey, gravelly to slightly gravelly SAND & SILT. Few scattered cobbles.
53.2 EL 145.9 = Top of Rock
DOLOMITE, hard, few thin beds of shale Occasional small slightly weathered seam Rock broken
73.2 EL 125.9
Core Recovery 85.5%

NOTES:

Analyses of overburden are based on dry samples.

Analyses of bed rock are based on 2½" rock cores obtained by drilling

Holes numbered less than D1500 drilled with 3½" casing.

Elevations based on USGS datum M.S.L. 1912 adj.

See sheet file no. M-C-A-1/6 for descriptive terms

See sheet file no. M-C-A-1/1 for coordinates of holes.

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION EXPLORATION NO. 2

IN 3 SHEETS SHEET NO 2 SCALE 1" = 20 FT

0 20 40

U.S ENGINEER OFFICE, MASSENA, N.Y. FEB 1941

SUBMITTED: R. M. Hanner ENGINEER

RECOMMENDED: Asst. HEAD CLERK

APPROVED: [illegible] CHIEF OF ENGINEERS

BY AUTHORITY OF THE CHIEF OF ENGINEERS

DRAWN BY [illegible]

CHECKED BY [illegible]

FILE NO. MC-A-2/15

TRANSMITTAL LETTER OR ENDORSEMENT

DATE ---------- 194

PLATE III -16

D-1196

0.0 EL. 1068

Fairly soft to soft, brown, reddish grey, slightly sandy, slightly silty CLAY. Fairly soft to soft grey, slightly silty CLAY.

11.8 EL. 1056.2

Fairly compact to compact, gravelly very silty SAND

20.0 EL. 1048.0

Top of Rock
DOLOMITE, dk. grey, hard, few thin beds of shale, considerable calcite throughout. Rock broken but unweathered

30.0 EL. 1038.0

Core recovery 84%

D-1197

0.0 EL. 1054.6

Soft, brownish grey, slightly sandy SILT & CLAY

4.0 EL. 1050.6

Soft, grey, variable silty to slightly silty CLAY.

10.0 EL. 1044.6

Fairly compact, grey, slightly gravelly, silty SAND

20.0 EL. 1034.6

Compact, grey, slightly gravelly silty SAND

21.5 EL. 1033 • Top of Rock
DOLOMITE, med. hard considerable calcite throughout. Apparently rapidly recemented breccia. Numerous seams and solution cavities. Rock very badly broken and weathered

18.8 EL. 1026.8

Core recovery 60.5%

D-1198

0.0 EL. 1063

Soft, brownish-grey, slightly sandy SILT & CLAY

6.0 EL. 1057

Loose, gray, CLAY.

4.5.0 EL. 1039.2

Fairly compact to compact, gray, gravelly silty to very silty SAND

DOLOMITE, dark gray, hard possible seams at 74.7 and 76.3. Rock broken and slightly weathered

74.7 EL. 1036.6
77.3 EL. 1034.0
77.6 EL. 1033.7

SHALE, black, pied, hard. Rock broken but unweathered

32.6 EL. 1027
37.0 EL. 1022.6
41.7 EL. 1017.9

DOLOMITE, light gray, considerable calcite throughout. Few thin beds of shale. Rock broken but unweathered

SHALE, black, few stringers of calcite. Rock broken but unweathered

DOLOMITE, light gray, fine grained, broken along few joints and partings. Rock unweathered

Core recovery 81%

D-1199

0.0 EL. 1060

Soft, brownish-grey, slightly sandy, slightly silty CLAY

12.8 EL. 1047.2

Soft, gray, CLAY

14.0 EL. 1046.0

Fairly soft, grey, slightly gravelly, silty, SAND.

16.5 EL. 1043.5

Compact, grey, slightly gravelly silty, SAND, occasional cobbles

38.1 EL. 1021.9 • Top of Rock
DOLOMITE, hard, badly broken and slightly weathered. Numerous broken zones and small seams. Considerable calcite and pyrite throughout.

41.2 EL. 1018.8

Core recovery 76.1%

D-1200

0.0 EL. 1034.4

Soft, variable grey silt from to grey, silty to slightly silty CLAY

6.5 EL. 1027.9
8.0 EL. 1026.4
13.0 EL. 1021.4

Soft, grey, slightly sandy, slightly silty CLAY

Loose grey slightly clayey, slightly gravelly, silty SAND.

Fairly compact to compact, grey, slightly gravelly, silty SAND occasional cobbles

18.0 EL. 1016.4 • Top of Rock
DOLOMITE, hard numerous stringers and reveins of shale. Rock broken and slightly weathered

SHALE, black, sandy. Rock broken but unweathered

DOLOMITE interbedded with shale. Slight amount of solution evident. Rock broken and slightly weathered

Core recovery 92.6%

D-1201

0.0 EL. 1032.3

Fairly compact, brownish grey, silty, CLAY

12.0 EL. 1020.3

Fairly soft, gray, CLAY

23.0 EL. 1013.3
27.0 EL. 1009.3

Fairly compact, grey, slightly gravelly, slightly clayey, sandy SILT

Compact grey, slightly gravelly, silty SAND

36.0 EL. 1000 • Top of Rock
DOLOMITE, dk. grey, hard, few thin beds of shale. Considerable calcite throughout. Few stringers slightly weathered seams.

39.0 EL. 993

Core recovery 95.5%

D-1202

0.0 EL. 1033

Fairly soft, brown to grey, variable SILT & CLAY

13.3 EL. 1019.7

Fairly soft, grey, CLAY

Compact, grey, slightly gravelly, silty, SAND

26.0 EL. 1007 • Top of Rock
DOLOMITE & SHALE interbedded few small soft inclusions and thin veins of calcite throughout. Few small slightly weathered seams.

26.7 EL. 1006.3

Rock is apparently sound.

Core recovery 94%

D-1203

0.0 EL. 1035.6

Fairly soft, brownish grey, silty CLAY

13.0 EL. 1022.6

Variable fairly soft to compact, grey, CLAY

22.0 EL. 1013.6

Compact, grey, slightly clayey, slightly gravelly, silty, SAND

22.0 EL. 1013.6 • Top of Rock
DOLOMITE, hard, considerable calcite throughout. Few small possible seams. Occasional shale bed. Rock moderately broken but unweathered

22.0 EL. 1013.6

Core recovery 92%

D-1204

0.0 EL. 1127.7

Fairly soft, brownish grey, silty CLAY.

12.3 EL. 1115.4

Soft grey CLAY

60.5 EL. 1067.2 • Top of Rock
LIMESTONE, hard, considerable calcite throughout. Rock sound & unweathered

74.8 EL. 1052.9

DOLOMITE, interbedded with shale, hard. Broken along occasional partings. Rock sound and apparently unweathered

88.6 EL. 1039.1

Core recovery 90%

D-1205

0.0 EL. 1122.9

Fairly soft, brown, slightly sandy, silty CLAY

14.0 EL. 1108.9

Soft grey CLAY

60.1 EL. 1062.8

DOLOMITE, interbedded with shale, few small apparent seams. Slight amount of solution. Rock slightly weathered and moderately broken.

90.5 EL. 1032.4

Core Recovery 90.6%

D-1209

0.0 EL. 154.2

WATER

14.5 EL. 139.7 Top of Overburden
Soft black, slightly sandy, slightly clayey organic SILT.

31.5 EL. 132.7

Soft grey silty CLAY.

42.0 EL. 112.2

DOLOMITE, medium grey hard. Few thin beds and stringers of shale. Some solution throughout. Rock broken and slightly weathered.

62.0 EL. 92.2

Core recovery 83.0%

D-1210

0.0 EL. 135.2

WATER

3.0 EL. 132 Top of Overburden
Soft grey slightly sandy silty CLAY.

56.0 EL. 82.2

DOLOMITE dark grey hard few thin beds of shale Rock sound and slightly weathered on few small seams

78.0 EL. 57.2

Core Recovery 85%

D-1211

0.0 EL. 136.2

WATER

28.0 EL. 108.2 Top of Overburden
Soft gray slightly sandy silty CLAY.

Apparently compact gray slightly gravelly slightly clayey silty SAND. Sample appears slightly

41.8 EL. 94.4
43.0 EL. 93.2
44.9 EL. 91.3
46.6 EL. 89.6
47.2 EL. 89.0
51.4 EL. 84.8

rotted

LIMESTONE dolomitic dark gray hard Very badly dissolved with a possible solution cavity. Rock broken, slightly weathered.

DOLOMITE dark gray fine grained, interbedded with shale. Small amount of solution. Rock moderately broken and slightly weathered

SHALE black hard, calcitic. Rock broken slightly weathered.

DOLOMITE med. to dark gray hard. Few thin beds of shale unweathered.

Core Recovery 97.5%

D-1212

0.0 EL. 134.2

No soil samples

90.0 EL. 113.2

DOLOMITE interbedded with shale, few small broken and weathered zones. Some solution thruout.

Core recovery 79.0%

D-1213

0.0 EL. 134.2

WATER

Top of Overburden

92.0 EL. 111.4
96.2 EL. 100.0

Compact grey slightly gravelly slightly clayey silty SAND.

DOLOMITE, hard, few thin beds of shale. Rock slightly weathered and broken.

Core recovery 82.5%

D-1214

0.0 EL. 135.7

Fairly compact, grey, slightly sandy, silty, CLAY

10.0 EL. 125.7
22.5 EL. 113.2

Compact, grey, CLAY

Very compact, grey, slightly gravelly, silty, SAND occasional boulders

90.3 EL. 57.4 • Top of Rock
DOLOMITE, hard, occasional thin beds of shale few broken zones and pass bits seams with considerable amount of solution throughout. Rock broken and slightly weathered

118.3 EL. 29.4

Core recovery 88.0%

D-1215

0.0 EL. 135.7

Soft, brownish grey & grey SILT & CLAY

11.4 EL. 124.3

Fairly loose, grey, gravelly, very silty SAND

33.2 EL. 102.5

Compact, grey, gravelly very silty SAND & SAND & SILT

60.1 EL. 75.6 • Top of Rock
DOLOMITE hard, occasional thin beds and stringers of shale. Some solution and few small open cavities. Rock slightly weathered and moderately broken

70.1 EL. 65.6

Core recovery 85%

D-1216

0.0 EL. 133.9

Soft, brownish grey clayey SILT

12.5 EL. 121.4

Fairly compact, grey gravelly, very silty SAND

Compact, grey, gravelly very silty SAND & SAND & SILT

45.0 EL. 88.9 • Top of Rock
DOLOMITE, dk. grey, hard few stringers of shale and few calcite crystals. Some solution possible small open cavities. GYPSUM zone from 93'6" to 99'. Rock apparently sound, but with few small weathered zones.

49.1 EL. 84.8
49.3 EL. 84.6
50.0 EL. 83.9

SHALE, black, med. hard. Few calcite crystals. Rock sound and unweathered.

DOLOMITE, dk grey hard. Broken along GYPSUM filled parting. Rock sound and unweathered.

Core recovery 92.9%

D-1261

0.0 EL. 135.6

Fairly compact to soft, brown, then grey CLAY and SILT to clayey, slightly sandy SILT

14.0 EL. 121.6

Soft grey slightly sandy silty CLAY

34.7 EL. 101.2

Compact grey, gravelly to slightly gravelly SAND and SILT

Compact grey, gravelly to slightly gravelly SAND and SILT

49.1 EL. 86.8 • Top of Rock
DOLOMITE, hard, few thin beds of shale. Numerous thin zones. Slight amount of weathering

Core recovery 79%

D-1262

0.0 EL. 135.7

Fairly compact grey slightly clayey slightly sandy SILT, shale

13.5 EL. 122.2

Soft grey slightly sandy silty CLAY.

35.4 EL. 100.3

Compact grey slightly gravelly SAND & SILT

51.5 EL. 84.2

Loose grey silty SAND

59.5 EL. 76.2

Compact grey slightly gravelly SAND & SILT

64.0 EL. 71.7 • Top of Rock

DOLOMITE, fault breccia partly recemented with calcite. Entire core badly fractured and weathered

67.2 EL. 68.5

Core Recovery 55%

D1266

0.0 EL. 134.1

Compact brown to grey slightly gravelly SAND & SILT.

13.0 EL. 121.1

Compact or very compact grey slightly gravelly SAND and SILT.

73.0 EL. 61.1 Top of Rock.
DOLOMITE, medium gray, hard with thin beds of shale. Broken along joints and few small broken zones.

82.8 EL. 51.3

Core Recovery 92%

TRANSVERSE MERCATOR COORDINATES

HOLE NO	NORTH	EAST	HOLE NO	NORTH	EAST
D-1196	1,817,056.69	384,065.98	D-1210	1,818,946.10	387,352.44
D-1197	1,818,112.71	384,377.53	D-1211	1,818,412.40	388,079.30
D-1198	1,817,940.41	384,258.73	D-1212	1,819,311.35	389,690.64
D-1199	1,818,180.01	384,271.53	D-1213	1,818,512.20	389,[illegible]09
D-1200	1,818,611.61	384,[illegible]3	D-1214	1,817,987.96	389,634.74
D-1201	1,818,[illegible]	384,[illegible]3	D-1215	1,817,870.65	389,250.64
D-1202	1,818,[illegible]	384,[illegible]3	D-1216	1,817,793.36	388,866.15
D-1203	[illegible]	[illegible]	D-1261	1,818,010.56	389,897.59
D-1204	[illegible]	[illegible]	D-1262	1,818,[illegible]3	389,[illegible]3
D-1205	[illegible]	[illegible]	D-1266	[illegible]	[illegible]
D-1209	[illegible]	[illegible]			

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
RECORD OF FOUNDATION EXPLORATION NO 3

IN SHEETS SHEET NO SCALE: 1"=20ft

U.S. ENGINEER OFFICE, MASSENA N.Y. 7,193

SUBMITTED: R.M. Hanner ENGINEER

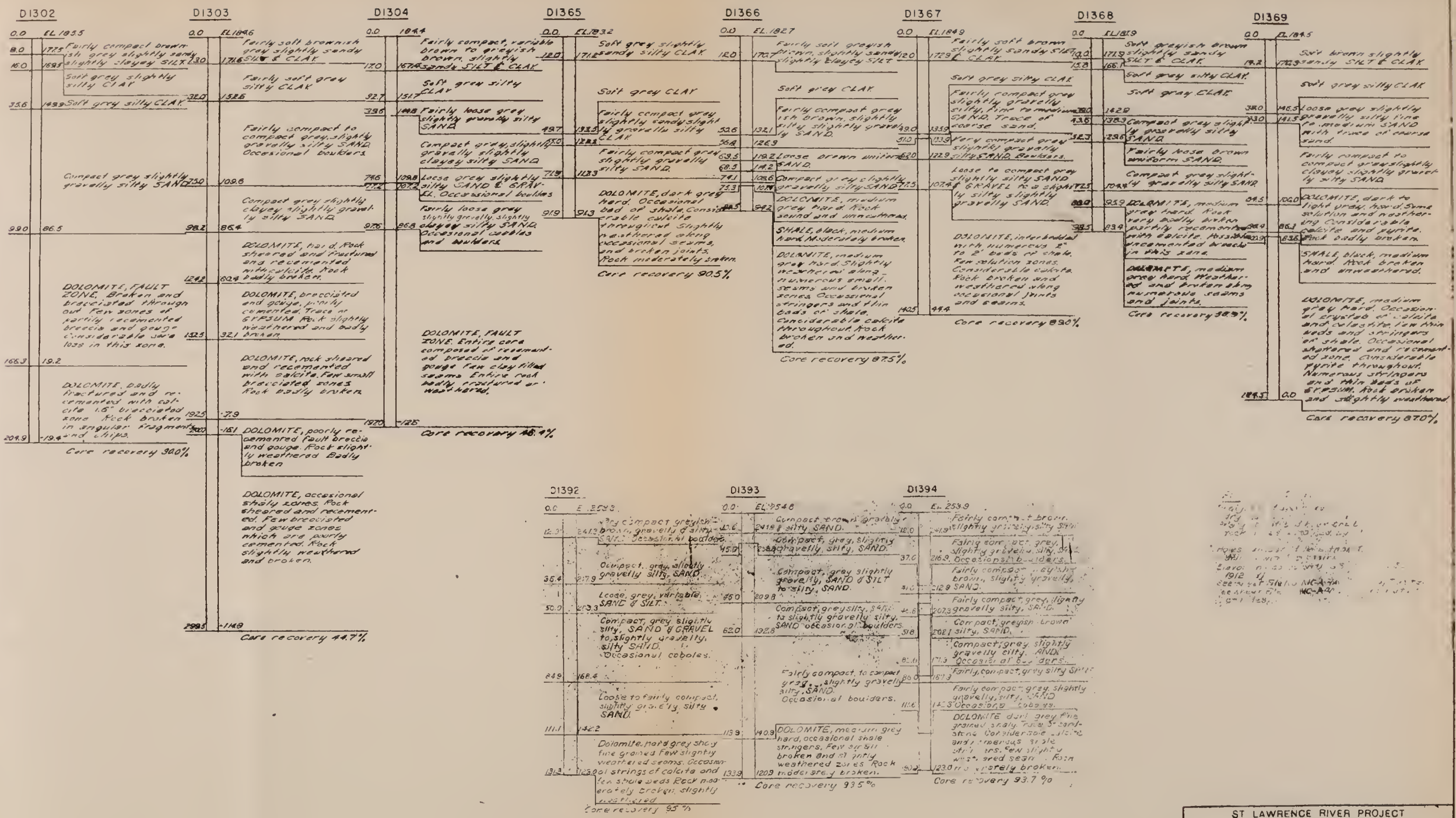
RECOMMENDED: [illegible] ENGR

APPROVED: A.D. Jones COL. CORPS OF ENGINEERS DIST. ENGR

DRAWING NO. MC-A-2/16
CHECKED BY:
FILE NO:

TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 194

PLATE III 17.


D1302
0.0 EL 1935
8.0 1775 Fairly compact brownish grey slightly sandy slightly clayey SILT
16.0 1693
Soft grey slightly silty CLAY
33.6 1439 Soft grey silty CLAY
Compact grey slightly gravelly silty SAND
99.0 86.5 98.2
DOLOMITE, FAULT ZONE. Broken and brecciated through out few zones of partly recemented breccia and gouge. Considerable core loss in this zone.
166.3 19.2
DOLOMITE, badly fractured and recemented with calcite 1.5" brecciated zone. Rock broken in angular fragments and chips.
209.9 -19.4
Core recovery 90.0%
D1303
0.0 EL 1846
Fairly soft brownish gray slightly sandy SILT & CLAY
13.0 1716
Fairly soft grey silty CLAY
32.0 1525
Fairly compact to compact grey, slightly gravelly silty SAND. Occasional boulders
75.0 109.6
Compact grey slightly clayey slightly gravelly silty SAND
99.2 86.4
DOLOMITE, hard rock sheared and fractured and recemented with calcite. Rock badly broken.
124.2 60.4
DOLOMITE, brecciated and gouge, poorly cemented. Trace of GYPSUM. Rock slightly weathered and badly
132.5 32.1 broken.
DOLOMITE, rock sheared and recemented with calcite. Few small brecciated zones. Rock badly broken.
192.5 -7.9
200 -16.1 DOLOMITE, poorly recemented fault breccia and gouge. Rock slightly weathered Badly broken
DOLOMITE, occasional shaly zones. Rock sheared and recemented. Few brecciated and gouge zones which are poorly cemented. Rock slightly weathered and broken.
299.5 -116.8
Core recovery 44.7%
D1304
0.0 1844
Fairly compact, variable brown to greyish brown, slightly
12.0 1674 sandy SILT & CLAY
Soft grey silty CLAY
32.7 1517
39.6 1468 Fairly loose grey slightly gravelly SAND & GRAVEL. Occasional boulders
49.7 1323
Compact grey, slightly clayey silty SAND.
71.9 1183
74.6 109.8 Loose grey slightly
77.2 107.2 silty SAND & GRAVEL. Occasional boulders
Fairly loose grey slightly gravelly, slightly clayey silty SAND. Occasional cobbles and boulders.
91.9 86.8 97.6
DOLOMITE, FAULT ZONE. Entire core composed of recemented breccia and gouge. Few clay filled seams. Entire rock badly fractured or weathered.
Core recovery 46.4%
D1365
0.0 EL 1832
12.0 1712 Soft grey slightly sandy silty CLAY
Soft grey CLAY
Fairly compact grey slightly sandy slightly gravelly silty CLAY
33.5 1323
35.0 1283
Fairly compact grey slightly gravelly silty SAND.
69.5 1192
68.5 114.2
74.1 108.6
75.3 107.4
DOLOMITE, dark grey hard. Occasional bed of shale. Considerable erodic calcite throughout. Slightly weathered along occasional seams, and broken joints. Rock moderately broken.
89.5 89.2
91.9
Core recovery 90.5%
D1366
0.0 EL 1827
Fairly soft greyish brown, slightly sandy slightly clayey SILT
12.0 1707
Soft grey CLAY
Fairly compact grey ish brown, slightly silty slightly gravelly SAND.
32.6 1321
49.0 1335
51.0 1331
Loose brown uniform SAND.
63.5 1192
68.5 114.2
74.1 108.6
Compact grey slightly gravelly silty SAND.
75.3 107.4
DOLOMITE, medium grey hard rock sound and unweathered.
SHALE, black, medium hard. Moderately broken.
DOLOMITE, medium grey hard. Slightly weathered along numerous small seams and broken zones. Occasional stringers and thin beds of shale. Considerable calcite throughout. Rock broken and weathered.
142.5 44.4
Core recovery 87.5%
D1367
0.0 EL 1849
Fairly soft brown slightly sandy SILT & CLAY
12.0 1729
Soft grey silty CLAY
Fairly compact grey slightly gravelly silty, fine to medium SAND. Trace of coarse sand.
49.0 1335
51.0 1331
Very compact grey slightly gravelly SAND. Boulders.
62.0 1329 silty SAND. Boulders
Loose to compact grey slightly silty SAND & GRAVEL to a slightly silty slightly gravelly SAND.
107.5 99.4
DOLOMITE, interbedded with numerous 2" to 2' beds of shale. Few solution zones. Considerable calcite. Rock broken and weathered along occasional joints and seams.
142.5 44.4
Core recovery 89.0%
D1368
0.0 EL 1819
Soft greyish brown slightly sandy SILT & CLAY
15.8 1661
Soft grey silty CLAY
Soft gray CLAY
38.0 1629
43.6 1623.3 Compact grey slightly gravelly silty SAND
Fairly loose brown uniform SAND.
Compact grey slightly gravelly silty SAND
104.4 93.9
DOLOMITE, medium gray hard rock very badly broken partly recemented with calcite. Numerous uncemented breccia in this zone.
DOLOMITE, medium grey hard weathered and broken with numerous seams and joints.
Core recovery 98.9%
D1369
0.0 EL 1845
Soft brown slightly
19.2 1763 sandy SILT & CLAY
Soft grey silty CLAY
Loose grey slightly
38.0 146.5 gravelly silty fine
43.0 141.5 to medium SAND with trace of coarse sand.
Fairly compact to compact grey slightly clayey slightly gravelly silty SAND
DOLOMITE, dark to light grey, hard. Some solution and weathering. Considerable calcite and pyrite. Rock badly broken.
84.5 100.0
86.4
83.6
SHALE, black, medium hard. Rock broken and unweathered.
DOLOMITE, medium gray hard. Occasional crystals of calcite and celestite. Few thin beds and stringers of shale. Occasional shattered and recemented zone. Considerable pyrite throughout. Numerous stringers and thin beds of GYPSUM. Rock broken and slightly weathered.
184.5 0.0
Core recovery 87.0%
D1392
0.0 EL 2593
Very compact greyish brown, gravelly silty
12.3 241.3 SAND. Occasional boulders.
45.0
Compact, grey, slightly gravelly silty, SAND.
36.4 217.9
Loose, grey, variable SAND & SILT.
50.0 203.3
Compact, grey slightly silty, SAND & GRAVEL to slightly gravelly, silty SAND. Occasional cobbles.
84.9 168.4
Loose to fairly compact, slightly gravelly silty SAND.
111.1 142.2
Dolomite, hard grey shaly fine grained few slightly weathered seams. Occasional strings of calcite and few shale beds. Rock moderately broken, slightly weathered
131.3 123.9
Core recovery 95%
D1393
0.0 EL 2546
Compact, brown, gravelly
10.6 241.8 silty, SAND.
Compact, grey, slightly gravelly, silty, SAND.
37.0
Compact, grey slightly gravelly, SAND & SILT to silty, SAND.
81.0 209.8
Compact, grey silty, SAND to slightly gravelly silty, SAND. Occasional boulders.
120.0 192.8
Fairly compact, to compact grey, slightly gravelly silty, SAND. Occasional boulders.
DOLOMITE, medium grey hard, occasional shale stringers. Few small broken and slightly weathered zones. Rock
133.9 140.9 moderately broken.
Core recovery 93.5%
D1394
0.0 EL 2539
Fairly compact brown slightly gravelly silty SAND
Fairly compact, grey, slightly gravelly silty, SAND
216.9 Occasional boulders.
Fairly compact, greyish brown, slightly gravelly, 212.9 SAND.
Fairly compact, grey, slightly gravelly, silty, SAND.
Compact, greyish brown silty, SAND.
Compact, grey, slightly gravelly silty, SAND
Occasional boulders.
Fairly compact, grey silty SAND
Fairly compact grey, slightly gravelly, silty, SAND
Occasional boulders.
DOLOMITE dark grey fine grained shaly rock & sandstone. Considerable shale and numerous small shaly and sandy seams. Few slightly weathered seams. Rock
123.0 moderately broken.
Core recovery 93.7%

ST LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION EXPLORATION

NO. 4

IN SHEETS SHEET NO. SCALE 1" = 20' VERTICAL

U. S. ENGINEER OFFICE, MASSENA, NEW YORK

SUBMITTED: R. M. Hazard

RECOMMENDED: L. J. Tyler, G. Butler

APPROVED: R. L. Jones

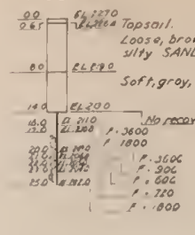
DRAWN BY: REED

FILE NO. MC-A 2/17

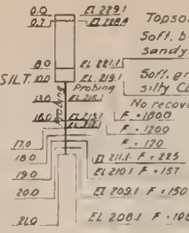
TRANSMITTED WITH LETTER OF ENDORSEMENT DATED

PLATE III 18

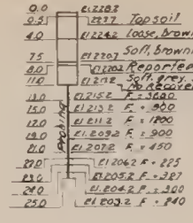
T-1500 a



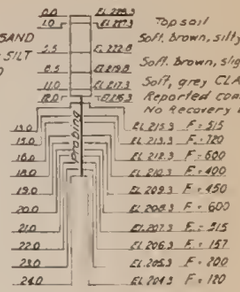
T-1501 a



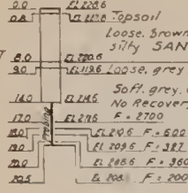
T-1502 a


0.0 EL 228.3
0.5 EL 227.7 Topsoil
4.0 EL 224.2 Loose, brown, slightly silty SAND
7.5 EL 220.7 Soft, brownish-grey, sandy SILT
8.0 EL 220.2 Reported fine SAND
11.0 EL 217.2 Soft, grey SILT & SAND
No recovery below 11.0
Probing
13.0 EL 215.2 F. = 3600
15.0 EL 213.2 F. = 900
17.0 EL 211.2 F. = 1800
18.0 EL 210.2 F. = 900
19.0 EL 209.2 F. = 450
20.0 EL 208.2 F. = 600
21.0 EL 207.2 F. = 450
EL 206.2 F. = 225
23.0 EL 205.2 F. = 387
24.0 EL 204.2 F. = 300
25.0 EL 203.2 F. = 240

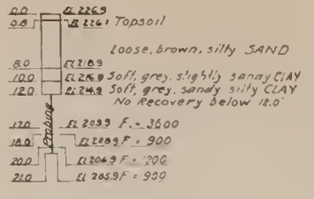
T-1503 a


0.0 EL 228.3
1.0 EL 227.3 Topsoil
Soft, brown, silty SAND
2.5 EL 225.8 Soft, brown, slightly sandy SILT
6.5 EL 221.8 Soft, grey CLAY
11.0 EL 217.3 Reported coarse SAND
18.0 EL 210.3 No Recovery below 12.0'
Probing
13.0 EL 215.3 F = 515
15.0 EL 213.3 F = 720
16.0 EL 212.3 F = 600
18.0 EL 210.3 F = 400
19.0 EL 209.3 F = 450
20.0 EL 208.3 F = 600
21.0 EL 207.3 F = 515
22.0 EL 206.3 F = 157
23.0 EL 205.3 F = 700
24.0 EL 204.3 F = 120

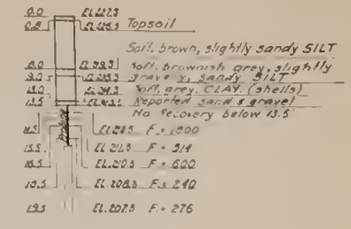
T-1504 a


0.0 EL 226.6
0.8 EL 225.8 Topsoil
Loose, brown, slightly silty SAND
8.0 EL 218.0
9.0 EL 217.6 Loose, grey silty SAND
Soft, grey, CLAY
14.0 EL 213 No Recovery below 14.0'
Probing
17.0 EL 210.5 F = 2700
18.0 EL 209.6 F = 600
19.0 EL 208.6 F = 387
20.0 EL 207.6 F = 360
EL 205 F = 200

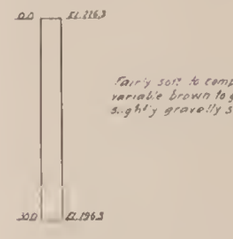
T-1505 a


0.0 EL 226.9
0.8 EL 226.1 Topsoil
Loose, brown, silty SAND
8.0 EL 218.9
10.0 EL 216.9 Soft, grey, slightly sandy CLAY
12.0 EL 214.9 Soft, grey, sandy silty CLAY
No Recovery below 12.0'
Probing
17.0 EL 209.9 F. = 3600
18.0 EL 208.9 F. = 900
20.0 EL 206.9 F. = 1200
21.0 EL 205.9 F. = 900

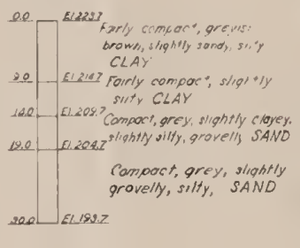
T-1507 a


0.0 EL 227.3
0.8 EL 226.5 Topsoil
Soft, brown, slightly sandy SILT
6.0 EL 221.3 Soft, brownish-grey, slightly sandy SILT
9.0 EL 218.3 grey sandy SILT
11.0 EL 216.3 Soft, grey, CLAY, (shells)
11.5 EL 215.8 Reported sand & gravel
No recovery below 13.5'
Probing
14.5 EL 212.8 F. = 1800
15.5 EL 211.8 F. = 314
16.5 EL 210.8 F. = 600
18.5 EL 208.8 F. = 240
19.5 EL 207.8 F. = 276

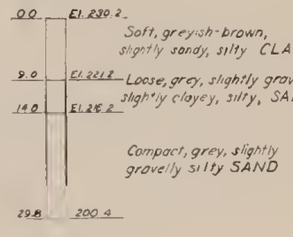
D-1508



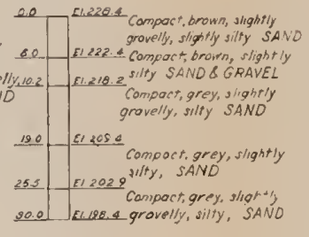
D-1509


0.0 EL 223.7
Fairly compact, greyish brown, slightly sandy, silty CLAY
3.0 EL 220.7 Fairly compact, slightly silty CLAY
14.0 EL 209.7 Compact, grey, slightly clayey, slightly silty, gravelly SAND
19.0 EL 204.2
Compact, grey, slightly gravelly, silty, SAND
30.0 EL 193.7

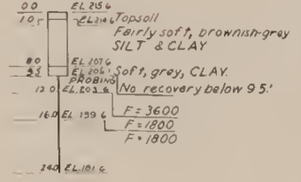
D-1510


0.0 EL 230.2
Soft, greyish-brown, slightly sandy, silty CLAY
9.0 EL 221.2 Loose, grey, slightly gravelly, slightly clayey, silty, SAND
14.0 EL 216.2
Compact, grey, slightly gravelly silty SAND
29.8 200.4

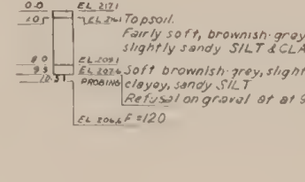
D-1511


0.0 EL 228.4
Compact, brown, slightly gravelly, slightly silty SAND
6.0 EL 222.4 Compact, brown, slightly silty SAND & GRAVEL
10.2 EL 218.2
Compact, grey, slightly gravelly, silty SAND
19.0 EL 209.4
Compact, grey, slightly silty, SAND
25.5 EL 202.9
Compact, grey, slightly gravelly, silty, SAND
30.0 EL 188.4

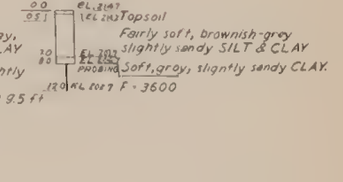
T-1513 a


0.0 EL 256
1.0 EL 254 Topsoil
Fairly soft, brownish-grey SILT & CLAY
8.0 EL 247
9.2 EL 245.8 Soft, grey, CLAY.
PROBING
12.0 EL 242.8 No recovery below 9.5'.
16.0 EL 238.8 F = 3600
F = 1800
F = 1800
24.0 EL 230.8

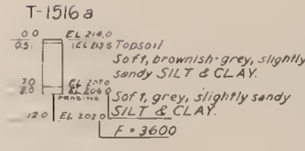
T-1514 a


0.0 EL 212.1
1.0 EL 211.1 Topsoil.
Fairly soft, brownish-grey, slightly sandy SILT & CLAY
8.0 EL 204.1
9.3 EL 202.8 Soft brownish-grey, slightly clayey, sandy SILT
PROBING
12.3 EL 200.8 Refusal on gravel at at 9.5 ft
EL 206.4 F=120

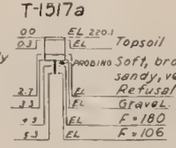
T-1515 a


0.0 EL 214.7
0.9 EL 213.8 Topsoil
Fairly soft, brownish-grey slightly sandy SILT & CLAY
1.0 EL 213.7
8.0 EL 207.7
PROBING
12.0 EL 203.7 Soft, grey, slightly sandy CLAY.
F = 3600

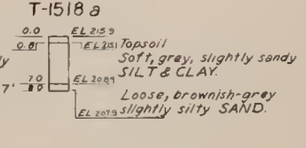
T-1516 a



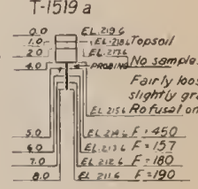
T-1517a


0.0 EL 220.1
0.3 EL Topsoil
PROBING Soft, brownish-grey, slightly sandy, very clayey SILT.
2.7 EL Refusal on gravel at 2.7'
3.3 EL Gravel.
+3 EL F = 180
5.3 EL F = 106

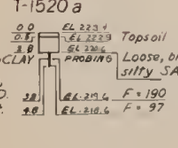
T-1518 a



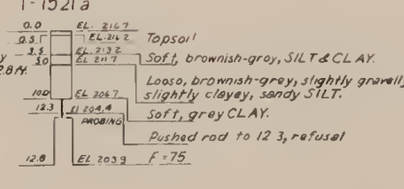
T-1519 a


0.0 EL 219.6
1.0 EL 218.6 Topsoil
2.0 EL 217.6
PROBING
4.0 No samples, apparently a silty CLAY
Fairly loose, brownish-grey, slightly gravelly SILT & SAND.
EL 214.6 Refusal on boulders at 4.0 ft.
5.0 EL 214.6 F = 450
6.0 EL 213.6 F = 157
7.0 EL 212.6 F = 180
8.0 EL 211.6 F = 190

T-1520 a


0.0 EL 223.4
0.8 EL 222.9 Topsoil
3.8 EL 220.6
PROBING
Loose, brown gravelly, very silty SAND. Refusal at 2.8 M.
2.8 EL 219.4 F = 190
4.8 EL 218.6 F = 97

T-1521 a


0.0 EL 214.7
0.5 EL 214.2 Topsoil
3.5 EL 211.2
3.0 EL 211.7 Soft, brownish-grey, SILT & CLAY.
Loose, brownish-grey, slightly gravelly, slightly clayey, sandy SILT.
10.0 EL 206.7
12.3 EL 204.4
PROBING
Soft, grey CLAY.
Pushed rod to 12 3, refusal
12.8 EL 203.9 F = 75

NOTES.

Analyses of overburden are based dry sampling.
Elevations are based on U.S.G.S. datum MSL. 1912 adj.
with 3" casing.
Holes numbered greater than D1500 drilled with 2½" casing.
T-----a denotes 5" diameter hand auger holes to refusal or no recovery and extended by hand probing. Probing made with ¾" rod driven with 14 lb sledge.
F-00 denotes rate of probing penetration in feet per hour.
See sheet File No. MC-A-¾ for descriptive terms.

TRANSVERSE MERCATOR COORDINATES

HOLE NO.	NORTH	EAST
T 1500 a	1,815,228.72	356,246.76
T 1501 a	1,815,538.93	356,924.36
T 1502 a	1,815,106.29	356,634.12
T 1503 a	1,815,416.44	357,311.73
T 1504 a	1,814,383.74	357,421.49
T 1505 a	1,814,861.24	358,008.85
T 1507 a	1,815,171.45	358,688.45
D1508	1,814,441.03	359,147.03
D1509	1,814,338.95	359,636.50
D1510	1,815,268.95	359,830.45
D1511	1,814,236.87	360,185.97
T 1513 a	1,814,194.68	361,205.08
T 1514 a	1,814,661.06	361,133.80
T 1515 a	1,814,336.32	361,827.01
T 1516 a	1,814,085.45	361,788.81
T 1517 a	1,814,086.41	362,695.56
T 1518 a	1,814,360.55	362,614.64
T 1519 a	1,814,594.46	363,045.07
T 1520 a	1,814,158.76	363,119.43
T 1521 a	1,814,259.71	363,710.88

ST LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION EXPLORATION NO. 5

IN SHEETS SHEET NO. SCALE: 1 IN = 10 FT.

0 10 0 10 20

U.S. ENGINEER OFFICE, MASSENA, NEW YORK FEBRUARY 1942

SUBMITTED: R. M. Hoover, ENGINEER

RECOMMENDED: [illegible], CHIEF ENGR; [illegible], LT. COL. CORPS OF ENGINEERS

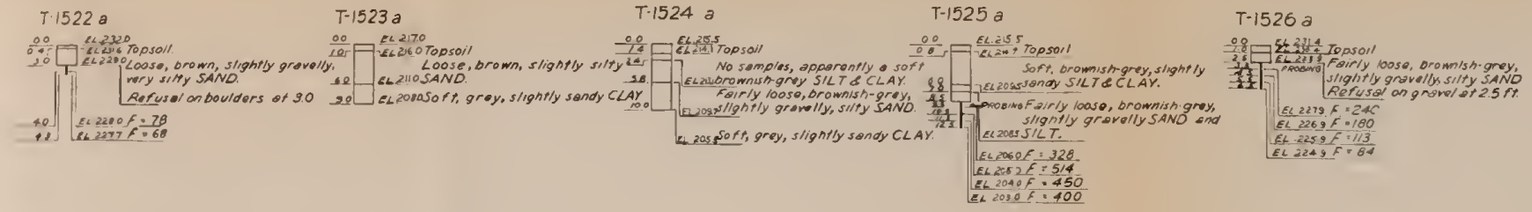
APPROVED: [illegible], DIVISION OF ENGINEERS, DISTRICT ENGINEER

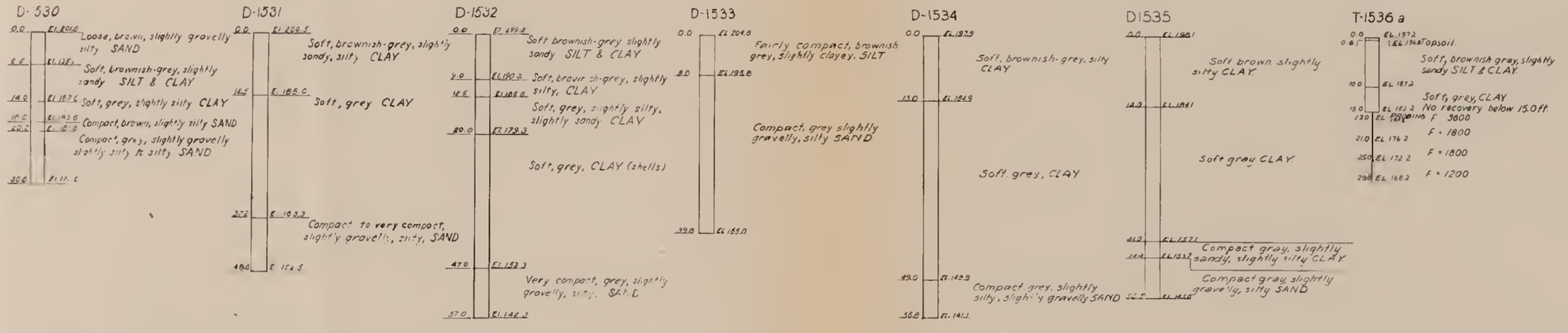
DRAWN BY A.R. CHECKED BY [illegible]

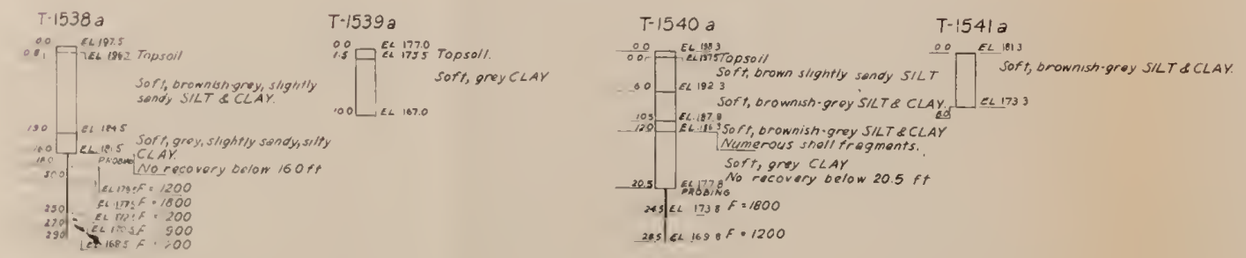
MC-A-2/F FILE NO

TRANSMITTED WITH LETTER OR ENDORSEMENT DATED , 194

PLATE III-19


T-1522 a
EL 232.0 Topsoil
EL 229.0 Loose, brown, slightly gravelly, very silty SAND.
Refusal on boulders at 3.0
EL 228.0 F = 78
EL 227.7 F = 68
T-1523 a
EL 217.0 Topsoil
EL 216.0 Loose, brown, slightly silty SAND.
EL 211.0 SAND.
EL 208.0 Soft, grey, slightly sandy CLAY
T-1524 a
EL 255.5 Topsoil
EL 214.1 No samples, apparently a soft brownish-grey SILT & CLAY.
EL 205.5 Fairly loose, brownish-grey, slightly gravelly, silty SAND.
Soft, grey, slightly sandy CLAY.
T-1525 a
EL 215.5 Topsoil
EL 214.7 Soft, brownish-grey, slightly sandy SILT & CLAY.
EL 205.5 PROBING Fairly loose, brownish-grey, slightly gravelly SAND and SILT.
EL 206.0 F = 328
EL 205.2 F = 514
EL 204.8 F = 450
EL 203.0 F = 400
T-1526 a
EL 231.4 Topsoil
EL 228.4 Fairly loose, brownish-grey, slightly gravelly, silty SAND
EL 228.3 PROBING Refusal on gravel at 2.5 ft.
EL 227.9 F = 240
EL 226.9 F = 180
EL 225.9 F = 113
EL 224.9 F = 84


D-1530
EL 201.6 Loose, brown, slightly gravelly silty SAND
EL 195.1 Soft, brownish-grey, slightly sandy SILT & CLAY
EL 187.6 Soft, grey, slightly silty CLAY
EL 183.6 Compact, brown, slightly silty SAND
EL 182.1 Compact, grey, slightly gravelly slightly silty to silty SAND
EL 171.6
D-1531
EL 209.5 Soft, brownish-grey, slightly sandy, silty CLAY
EL 186.6 Soft, grey CLAY
EL 183.2 Compact to very compact, slightly gravelly, silty, SAND
EL 154.5
D-1532
EL 199.9 Soft brownish-grey slightly sandy SILT & CLAY
EL 190.3 Soft, brownish-grey, slightly silty, CLAY
EL 186.6 Soft, grey, slightly silty, slightly sandy CLAY
EL 179.3
Soft, grey, CLAY (shells)
EL 152.3 Very compact, grey, slightly gravelly, silty, SAND
EL 142.2
D-1533
EL 204.8 Fairly compact, brownish grey, slightly clayey, SILT
EL 195.8 Compact, grey slightly gravelly, silty SAND.
EL 165.0
D-1534
EL 197.9 Soft, brownish-grey, silty CLAY
EL 184.9 Soft, grey, CLAY
EL 149.3 Compact, grey, slightly silty, slightly gravelly SAND
EL 141.1
D1535
EL 198.1 Soft brown, slightly silty CLAY.
EL 184.1 Soft gray CLAY.
EL 157.1 Compact gray, slightly sandy, slightly silty CLAY
EL 153.7 Compact gray, slightly gravelly, silty SAND
EL 141.6
T-1536 a
EL 197.2 Topsoil.
EL 196.8 Soft, brownish gray, slightly sandy SILT & CLAY.
EL 187.2 Soft, grey, CLAY
EL 185.2 No recovery below 15.0 ft.
PROBING F = 3600
F = 1800
EL 176.2 F = 1800
EL 172.2 F = 1200
EL 168.2



NOTES:

Any [illegible] overburden are based on dry samples.
Elevations are based on U.S.G.S. datum M.S.L. 1911 adjustment.

Hole numbered greater than 12.50 are 6" O.D. casing.
T--- denotes 5" diameter hard layer note, for refusal or rock, etc. and extended by 4 3/4" probing.
Fr ing made with 4" casing driven with 16" sledge.
F=00 denotes rate of probing penetrated in that number hours.
Reference File No. MC-A-2/14 for descriptive terms.

TRANSVERSE MERCATOR COORDINATES

HOLE NO.	NORTH	EAST	HOLE NO.	NORTH	EAST
T-1522	1,814,695.41	363,636.52	T-1533	1,815,372.46	368,075.17
T-1523	1,814,756.36	364,227.97	T-1534	1,815,079.08	369,511.46
T-1524	1,814,360.60	364,302.33	D-1535	1,815,488.30	368,644.50
T-1525	1,814,697.31	364,819.41	T-1536	1,815,181.71	369,112.78
T-1526	1,814,461.6	364,893.77			
			T-1538	1,815,272.57	369,645.08
			T-1539	1,815,373.52	370,236.51
D-1530	1,814,881.00	367,297.48	T-1540	1,815,482.88	370,877.24
D-1531	1,814,869.95	367,755.85	T-1541	1,815,910.16	370,753.60
D-1532	1,814,938.67	367,382.59			

ST LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION EXPLORATION NO. 6

IN... SHEETS SHEET NO. -- SCALE 1"=10'

10 0 10 20

U.S. ENGINEER OFFICE, MASSENA NEW YORK FEBRUARY, 1942

SUBMITTED: R. M. Hamer, ENGINEER

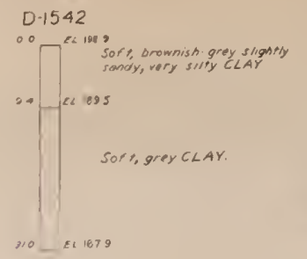
RECOMMENDED: E. Bullen, LT. COL. CORPS OF ENGINEERS, HEAD ENGR.

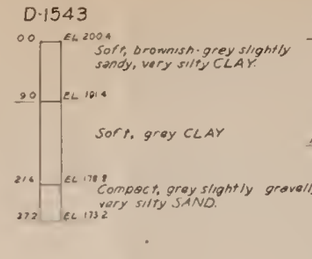
APPROVED: [signature], COLONEL OF ENGINEERS, DISTRICT ENGINEER

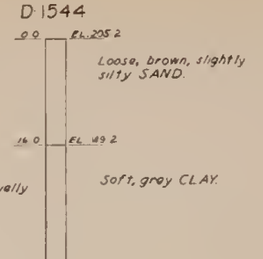
DRAWN BY AR. CHECKED BY [illegible] MC-A-2/10 FILE NO.

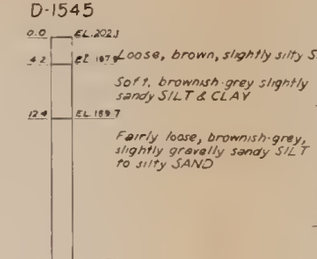
TRANSMITTED WITH LETTER OR ENDORSEMENT DATED - - ,194

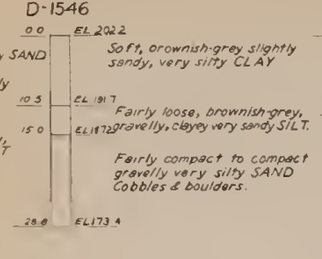
PLATE III

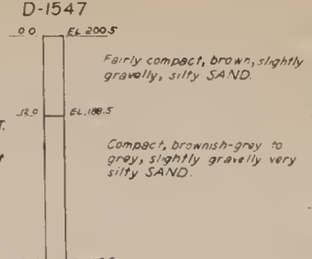


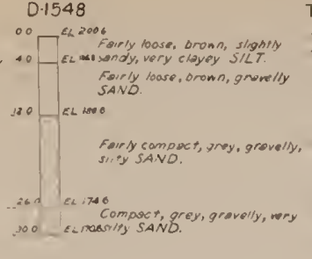


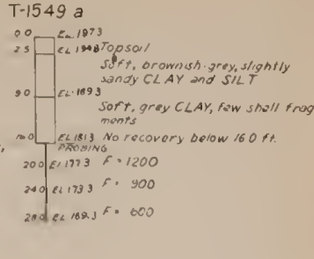


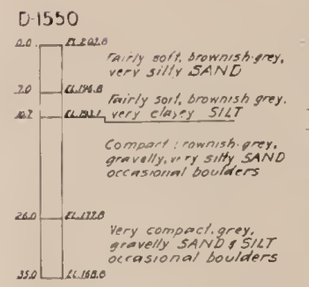

D-1545
0.0 EL. 202.1
4.2 EL 197.9
Loose, brown, slightly silty SAND
Soft, brownish-grey slightly sandy SILT & CLAY
12.4 EL 189.7
Fairly loose, brownish-grey, slightly gravelly sandy SILT to silty SAND
35.0 EL 167.1

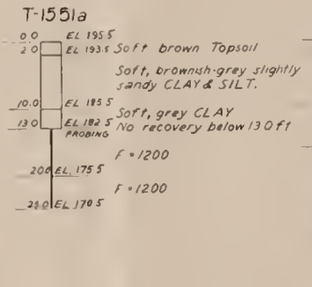

D-1546
0.0 EL 202.2
Soft, brownish-grey slightly sandy, very silty CLAY
10.5 EL 191.7
Fairly loose, brownish-grey, gravelly, clayey very sandy SILT.
15.0 EL 187.2
Fairly compact to compact gravelly very silty SAND Cobbles & boulders.
28.8 EL 173.4

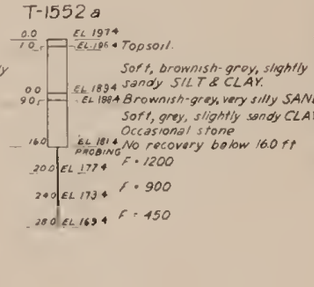

D-1547
0.0 EL 200.5
Fairly compact, brown, slightly gravelly, silty SAND.
12.0 EL 188.5
Compact, brownish-grey to grey, slightly gravelly very silty SAND.
33.0 EL 165.5

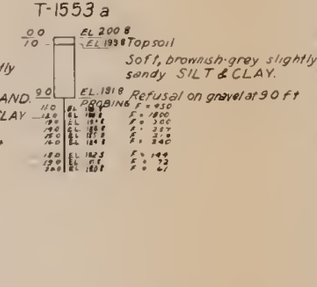

D-1548
0.0 EL 200.6
Fairly loose, brown, slightly
4.0 EL 196.6 sandy, very clayey SILT.
Fairly loose, brown, gravelly SAND.
12.0 EL 188.6
Fairly compact, grey, gravelly, silty SAND.
26.0 EL 174.6
Compact, grey, gravelly, very
30.0 EL 170.6 silty SAND.

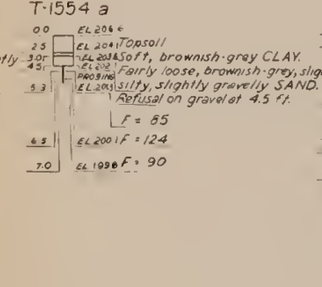

T-1549 a
0.0 EL 197.3
2.5 EL 194.8 Topsoil
Soft, brownish-grey, slightly sandy CLAY and SILT
9.0 EL 189.3
Soft, grey CLAY, few shell fragments
19.0 EL 181.3 No recovery below 16.0 ft.
PROBING
20.0 EL 177.3 F = 1200
24.0 EL 173.3 F = 900
28.0 EL 169.3 F = 600

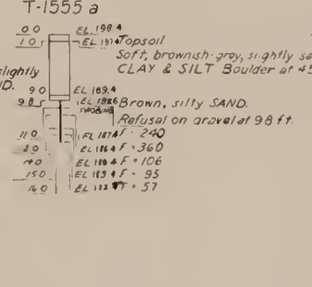

D-1550
0.0 EL 202.6
Fairly soft, brownish-grey, very silty SAND
7.0 EL 195.6
Fairly soft, brownish-grey, very clayey SILT
10.3 EL 192.3
Compact, brownish-grey, gravelly, very silty SAND occasional boulders
26.0 EL 177.0
Very compact, grey, gravelly SAND & SILT occasional boulders
33.0 EL 170.0

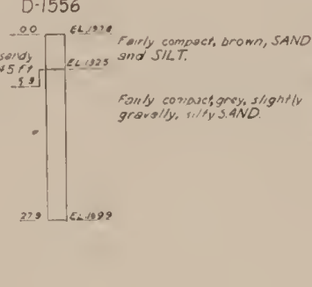


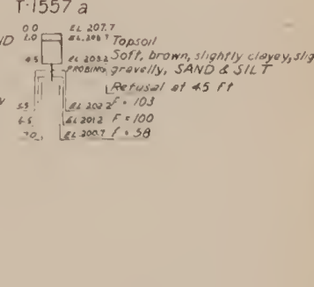


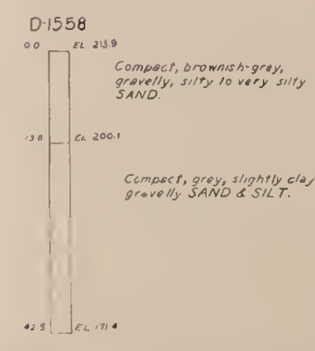


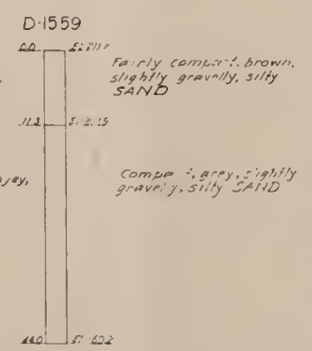

T-1554 a
0.0 EL 206.4
2.5 EL 204.1 Topsoil
3.0 EL 203.8 Soft, brownish-grey CLAY.
4.5 EL 202.3 Fairly loose, brownish-grey, slightly
PROBING silty, slightly gravelly SAND.
5.3 Refusal on gravel at 4.5 ft.
F = 85
6.3 EL 200.1 F = 124
7.0 EL 199.6 F = 90

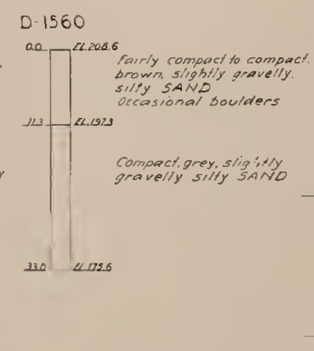

T-1555 a
0.0 EL 198.4
1.0 EL 197.4 Topsoil
Soft, brownish-grey, slightly sandy CLAY & SILT Boulder at 4.5 ft.
9.0 EL 189.4
9.8 EL 188.6 Brown, silty SAND.
PROBING
Refusal on gravel at 9.8 ft.
11.0 EL 187.4 F = 240
12.0 EL 186.4 F = 360
14.0 EL 184.4 F = 106
15.0 EL 183.4 F = 95
16.0 EL 182.4 F = 57

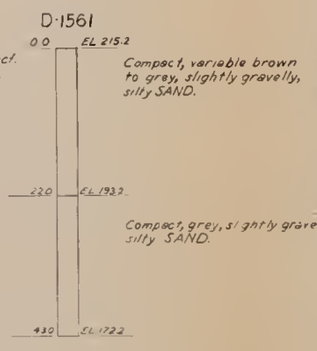


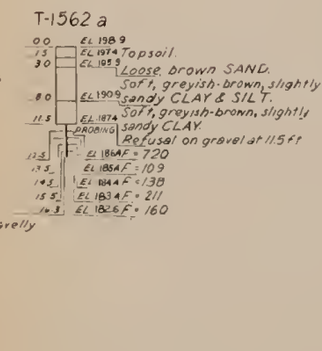

T-1557 a
0.0 EL 207.7
1.0 EL 206.7 Topsoil
4.5 EL 203.2 Soft, brown, slightly clayey, slightly
PROBING gravelly, SAND & SILT
Refusal at 4.5 ft
5.5 EL 202.2 F = 103
6.5 EL 201.2 F = 100
7.0 EL 200.7 F = 58

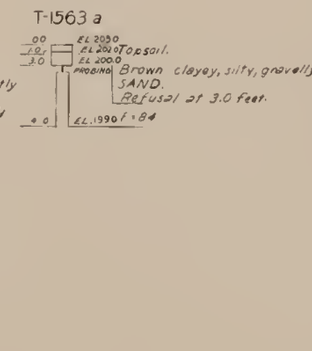

D-1558
0.0 EL 213.9
Compact, brownish-grey, gravelly, silty to very silty SAND.
13.8 EL 200.1
Compact, grey, slightly clayey, gravelly SAND & SILT.
41.5 EL 172.4

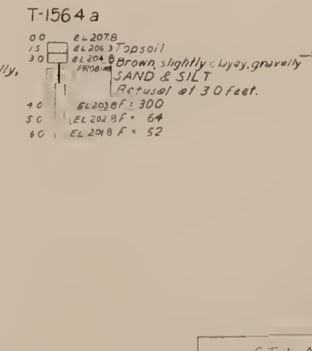



D-1560
0.0 EL 208.6
Fairly compact to compact, brown, slightly gravelly, silty SAND Occasional boulders
11.3 EL 197.3
Compact, grey, slightly gravelly silty SAND
33.0 EL 175.6


D-1561
0.0 EL 215.2
Compact, variable brown to grey, slightly gravelly, silty SAND.
22.0 EL 193.2
Compact, grey, slightly gravelly silty SAND.
43.0 EL 172.2


T-1562 a
0.0 EL 198.9
1.3 EL 197.4 Topsoil.
3.0 EL 195.3 Loose brown SAND.
Soft, greyish-brown, slightly
8.0 EL 190.9 sandy CLAY & SILT.
11.5 EL 187.4 Soft, greyish-brown, slightly
PROBING sandy CLAY.
Refusal on gravel at 11.5 ft
12.5 EL 186.4 F = 720
13.5 EL 185.4 F = 109
14.5 EL 184.4 F = 138
15.5 EL 183.4 F = 211
16.3 EL 182.6 F = 160




T-1564 a
0.0 EL 207.8
1.5 EL 206.3 Topsoil
3.0 EL 204.8 Brown, slightly clayey, gravelly
PROBING SAND & SILT
Refusal at 3.0 feet.
4.0 EL 203.8 F = 300
5.0 EL 202.8 F = 64
6.0 EL 201.8 F = 52

NOTES

Analyses of overburden are based on dry samples.

Elevations are based on USGS datum, MSL [illegible]

Holes numbered greater than D-1500 drilled with 2½" casing.

T-000's denotes 3" diameter hand auger holes to refusal or no recovery and extended by jetting through casing with ¾" rod driven with 1" ID.

Fill denotes rate of probing penetration in feet per hour.

See sheet File No. MC-[illegible] for core drill data.

TRANSVERSE MERCATOR COORDINATES

HOLE NO	NORTH	EAST	HOLE NO	NORTH	EAST
D1542	[illegible]	371,448.97	T1554a	1,618,615.64	376,681.22
D1543	[illegible]	372,010.85	T1555a	1,616,371.78	376,761.04
D1544	[illegible]	372,015.65	D1556	1,616,614.41	377,511.70
D1545	[illegible]	371,[illegible]	T1557a	1,616,335.56	377,532.50
D1546	[illegible]	372,014.10	D1558	1,616,615.11	377,968.58
D1547	[illegible]	373,[illegible]	D1559	1,617,[illegible]7.76	378,[illegible]
D1548	[illegible]	373,[illegible]	D1560	1,616,[illegible]	378,[illegible]
D1549	[illegible]	373,150	D1561	1,616,[illegible]	379,[illegible]
D1550	[illegible]	374,[illegible]	T1562a	1,616,[illegible]	379,[illegible]
D1551	[illegible]	374,[illegible]	T1563a	1,616,[illegible]	379,[illegible]
D1552	[illegible]	376,[illegible]	T1564a	1,616,[illegible]	379,[illegible]
D1553	[illegible]	376,[illegible]	T1554a	1,616,[illegible]	379,[illegible]

ST LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION EXPLORATION NO. 7

IN SHEETS SHEET NO SCALE 1" = 20'

U.S. ENGINEER OFFICE, MASSENA, NEW YORK FEBRUARY 194[illegible]

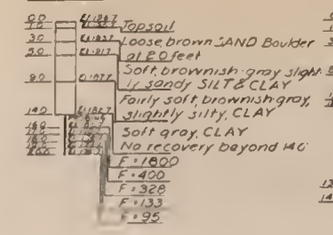
SUBMITTED P. M. Hainer ENGINEER

RECOMMENDED D. Sumner HEAD DIVISION

APPROVED [illegible] CHIEF CORPS OF ENGINEERS U.S. ARMY DISTRICT ENGINEER

DRAWN BY AE CHECKED BY AM FILE NO MC-A-212C TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 194

T-1565a



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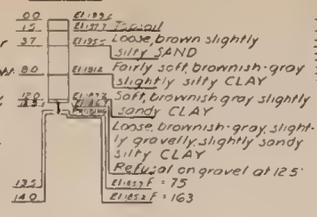
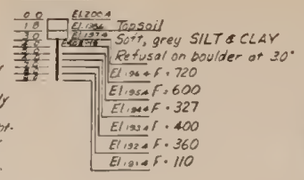

Topsoil
Loose, brown slightly silty SAND
Fairly soft, brownish-gray slightly silty CLAY
Soft, brownish gray slightly sandy CLAY
Loose, brownish-gray, slightly gravelly, slightly sandy silty CLAY
Refusal on gravel at 125'
F - 75
F - 163

T-1567a



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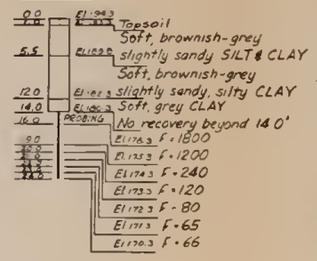
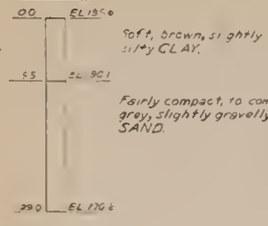


D-1569



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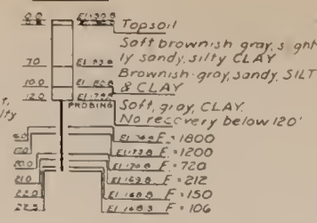

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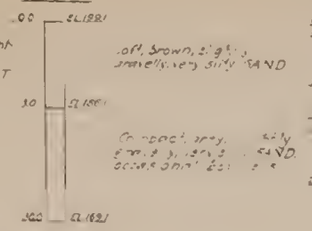

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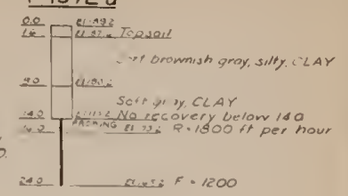

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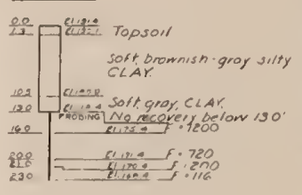

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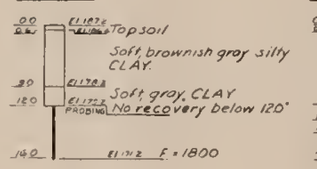

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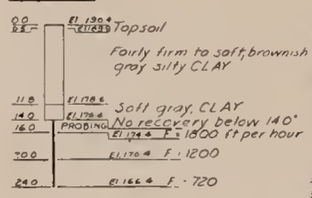

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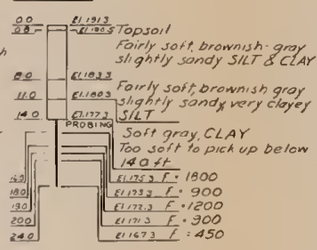
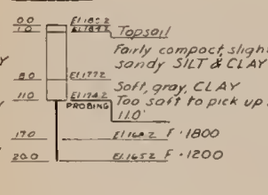

Topsoil
Fairly soft, brownish-gray slightly sandy SILT & CLAY
Fairly soft, brownish gray slightly sandy, very clayey SILT
Soft gray, CLAY
Too soft to pick up below 140 ft.
PROBING
F - 1800
F - 900
F - 1200
F - 300
F - 450

T-1577a



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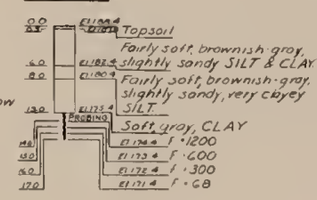
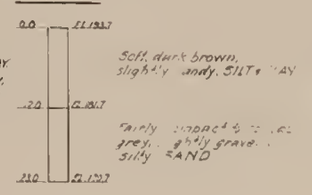
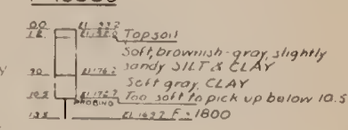


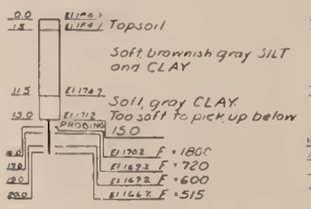
D-1579



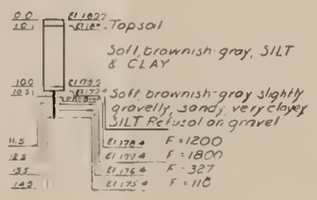
T-1580a



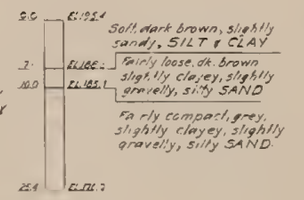
T-1581a



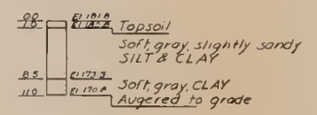
T-1582a



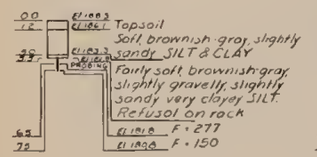
D-1583


Soft, dark brown, slightly sandy, SILT & CLAY
Fairly loose, dk. brown slightly clayey, slightly gravelly, silty SAND
Fairly compact, grey, slightly clayey, slightly gravelly, silty SAND

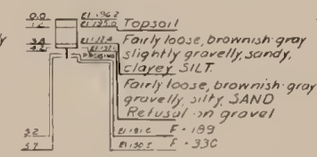
T-1584a



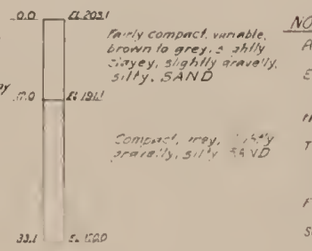
T-1585a


Topsoil
Soft, brownish-gray, slightly sandy SILT & CLAY
Fairly soft, brownish-gray, slightly gravelly, slightly sandy very clayey SILT.
Refusal on rock
F - 277
F - 150

T-1586a



D-1587


Fairly compact, variable, brown to grey, slightly clayey, slightly gravelly, silty, SAND
Compact, grey, slightly gravelly, silty SAND
33.1 S. LOAD

NOTES:

Analyses of overburden are based on visual examination of dry samples.
Elevations are based on USGS datum.
Mechanical equipment
Holes unlicensed greater than 3" diam. drilled with 2½" casing.
T000 - denotes 3" diameter hand auger holes to refusal or no recovery and extended by hand probing (probing is made with ¾" rod driven with 7 lb. sledge.
F-00 denotes rate of probing penetration in feet per hour.
See sheet File No. MC-A-2/6 for descriptive terms.

TRANSVERSE MERCATOR COORDINATES

HOLE NO.	NORTH	EAST	HOLE NO.	NORTH	EAST
T-1565a	1,816,[illegible]	376,[illegible]	T-1577a	1,817,323.4	379,033.85
T-1566a	1,816,[illegible]	376,[illegible]	T-1578a	1,817,007.0	379,087.85
T-1567a	1,816,44[illegible]	376,[illegible]	D-1579	1,816,887.7	379,108.2
T-1568a	1,816,[illegible]	376,[illegible]	T-1580a	1,817,424.4	378,875.30
D-1569	1,816,[illegible]	376,[illegible]	T-1581a	1,817,206.55	378,852.45
T-1570a	1,817,[illegible]	377,[illegible]	T-1582a	1,817,107.58	379,679.31
D-1571	1,816,[illegible]	377,[illegible]	D-1583	1,816,988.70	379,699.66
T-1572a	1,817,181.5[illegible]	377,[illegible]	T-1584a	1,817,525.31	380,218.76
T-1573a	1,816,585.[illegible]	377,[illegible]	T-1585a	1,817,307.50	380,263.5
T-1574a	1,817,[illegible]	376,[illegible]	T-1586a	1,817,208.93	380,277.74
T-1575a	1,816,[illegible]	376,[illegible]	D-1587	1,817,089.65	380,291.16
T-1576a	1,816,[illegible]	376,[illegible]			

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
RECORD OF FOUNDATION EXPLORATION NO 3

IN SHEETS SHEET NO SCALE: 1" = 0 Ft.

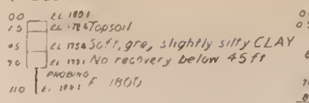
U.S. ENGINEER OFFICE MASSENA, N.Y.

SUBMITTED: R. M. Hunner, ENGINEER
RECOMMENDED: [illegible], CHIEF, [illegible] ENGINEERING
APPROVED: A. Flynn, COLONEL OF ENGINEERS, DISTRICT ENGINEER

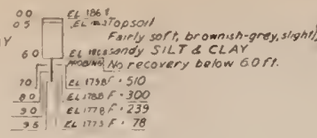
DRAWN BY: [illegible] CHECKED BY: [illegible]
MC-A-2/2. FILE NO.:
TRANSMITTED WITH LETTER OF ENDORSEMENT DATED [illegible] 194[illegible]

PLATE II-27

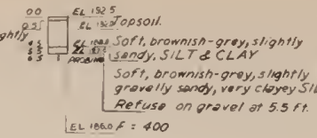
T-1588 a



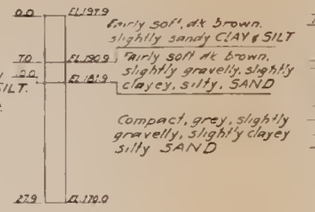
T 1589 a


EL 186.9
EL 186.3 Topsoil
Fairly soft, brownish-grey, slightly sandy SILT & CLAY
EL 176.8
PROBING
No recovery below 60 ft.
EL 175.8 F = 510
EL 176.8 F = 300
EL 177.8 F = 239
EL 177.3 F = 78

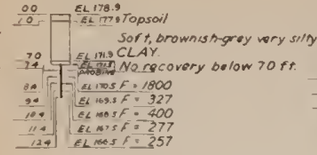
T-1590 a


EL 182.5
EL 182.0 Topsoil.
EL 176.8
PROBING
Soft, brownish-grey, slightly sandy, SILT & CLAY
Soft, brownish-grey, slightly gravelly sandy, very clayey SILT.
Refuse on gravel at 5.5 ft.
EL 186.0 F = 400

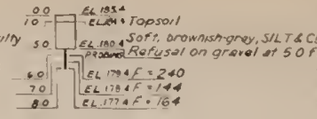
D-1591


EL 197.9
Fairly soft, dk brown, slightly sandy CLAY & SILT
Fairly soft dk brown, slightly gravelly, slightly clayey, silty, SAND
EL 180.9
EL 181.9
Compact, grey, slightly gravelly, slightly clayey silty SAND
EL 170.0

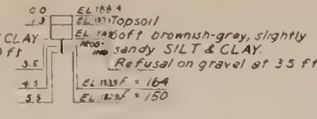
T-1592 a



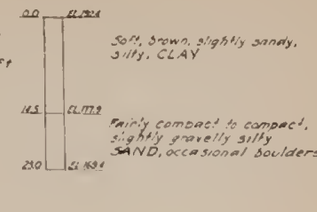
T-1593 a



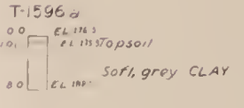
T-1594 a



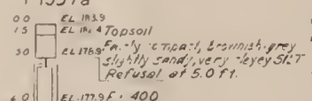
D-1595


EL 192.4
Soft, brown, slightly sandy, silty, CLAY
EL 177.9
Fairly compact to compact, slightly gravelly silty SAND, occasional boulders
EL 169.1

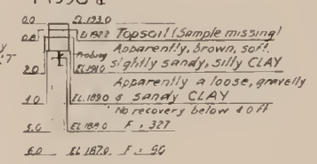
T-1596 a



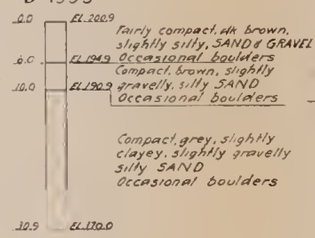
T-1597 a


EL 183.9
EL 182.4 Topsoil
Fairly compact, brownish-grey slightly sandy, very clayey SILT
Refusal at 5.0 ft.
EL 177.9 F = 400
EL 177.6 F = 120

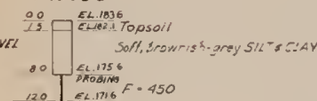
T-1598 a


EL 183.0
EL 182.0 Topsoil (Sample missing)
Apparently, brown, soft, slightly sandy, silty CLAY
PROBING
EL 176.0
Apparently a loose, gravelly sandy CLAY
No recovery below 6.0 ft
EL 177.0 F = 327
EL 187.9 F = 90

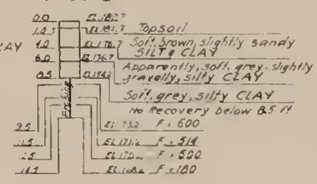
D-1599


EL 200.9
Fairly compact, dk brown, slightly silty, SAND & GRAVEL
EL 194.9 Occasional boulders
Compact, brown, slightly gravelly, silty SAND
EL 190.9
Occasional boulders
Compact, grey, slightly clayey, slightly gravelly silty SAND
Occasional boulders
EL 170.0

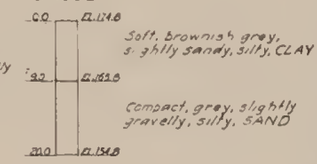
T-1600 a



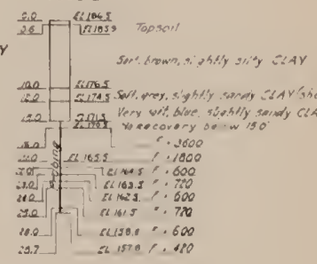
T-1601 a


EL 182.7
EL 181.7 Topsoil
EL 176.7 Soft, brown, slightly sandy SILT & CLAY
EL 174.6 Apparently, soft, grey, slightly gravelly, silty CLAY
PROBING
Soft, grey, silty CLAY
no recovery below 8.5 ft
EL 173.2 F = 600
EL 171.4 F = 516
EL 171.0 F = 500
EL 168.4 F = 180

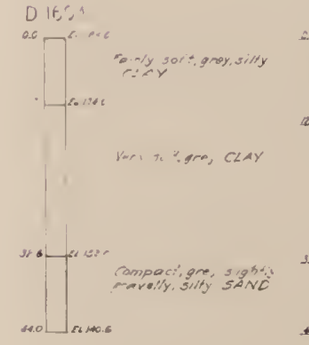
D-1602



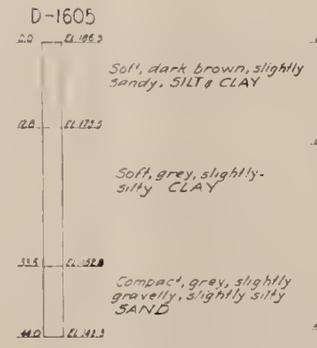
T-1603 a


EL 184.5
EL 183.9 Topsoil
Soft, brown, slightly silty CLAY
EL 176.5
EL 174.3 Soft, grey, slightly sandy CLAY (shells)
Very soft, blue, slightly sandy CLAY
EL 166.3 No recovery below 15.0
F = 3600
EL 165.5 F = 1800
EL 164.5 F = 600
EL 163.3 F = 720
EL 162.3 F = 600
EL 161.5 F = 720
EL 158.8 F = 600
EL 157.8 F = 420

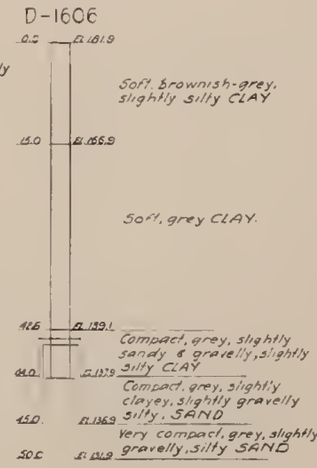
D 1604



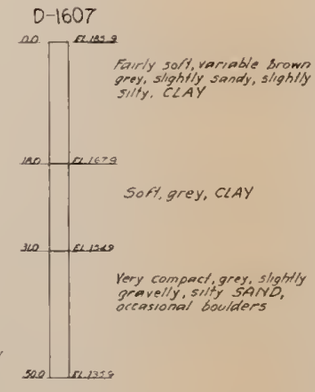
D-1605


EL 186.9
Soft, dark brown, slightly sandy, SILT & CLAY
EL 173.9
Soft, grey, slightly silty CLAY
EL 152.8
Compact, grey, slightly gravelly, slightly silty SAND
EL 142.9

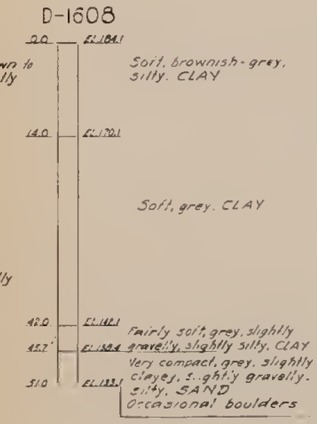
D-1606


EL 181.9
Soft, brownish-grey, slightly silty CLAY
EL 166.9
Soft, grey CLAY.
EL 139.1
Compact, grey, slightly sandy & gravelly, slightly silty CLAY
EL 137.9
Compact, grey, slightly clayey, slightly gravelly silty SAND
EL 136.9
Very compact, grey, slightly gravelly, silty SAND
EL 131.9

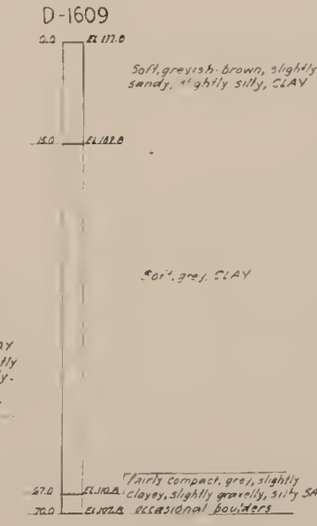
D-1607


EL 183.9
Fairly soft, variable brown to grey, slightly sandy, slightly silty, CLAY
EL 167.9
Soft, grey, CLAY
EL 134.9
Very compact, grey, slightly gravelly, silty SAND, occasional boulders
EL 133.9

D-1608



D-1609



TRAVERSE MERCATOR COORDINATES

	NORTH	EAST	HOLE NO	NORTH	EAST
	1,817,643.2	382,905.76	D-1600	1,817,919.26	382,520.34
	1,817,411.2	380,943.04	D1601	1,817,473.19	382,515.03
	1,817,351.7	380,960.76	D1602	1,817,272.1	383,120.19
	1,817,119.7	380,882.35	D 1603	1,818,091.39	383,566.28
	1,817,767.5	381,399.64	D1604	1,817,721.85	383,632.38
	1,817,903.4	381,430.88	D1605	1,818,164.65	383,968.57
	1,817,411.7	381,453.64	D1606	1,817,603.6	384,362.78
	1,817,725.5	381,474.00	D1607	1,818,450.5	384,573.19
	1,817,813.3	381,771.08	D1608	1,818,533.63	385,066.06
	1,817,606.5	382,227.26	D1609	1,817,649.83	385,825.76
	1,817,511.5	381,[illegible]			
	1,817,391.5	382,[illegible]			

NOTE:

Analyses of overburden are based on dry samples.
Elevations are based on U.S.G.S. datum M.L.W. 1912 adjustment.

Holes numbered greater than D1500 drilled with 2½" casing.
F000 denotes 2" diameter hand auger holes, to refusal and no recovery in test pits by hand probing. Probing made with ¾ rod driven with 14" sledge.
F.O. denotes rate of probing penetration in feet per hour.
See Test File No MC-A-3/14 for descriptive terms.

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION EXPLORATION NO. 9

IN SHEETS — SHEET NO. — — SCALE 1" = 10'

U.S. ENGINEER OFFICE, MASSENA, NEW YORK — FEBRUARY, 1942

SUBMITTED: P.M. Hammer, ENGINEER

RECOMMENDED: HEAD OF DIV.

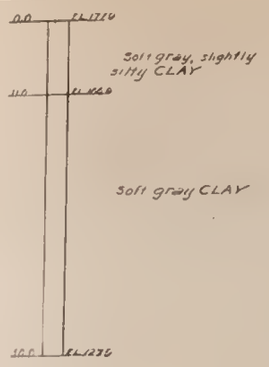
APPROVED: COL. CORPS OF ENGINEERS, DIVISION ENGINEER

DRAWN BY AE — CHECKED BY MM — MC-A-2/22 FILE NO

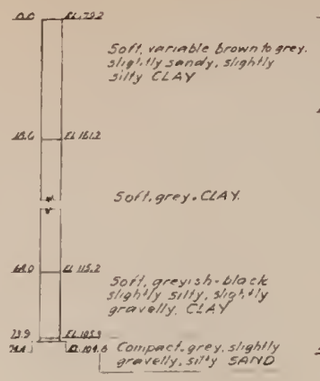
TRANSMITTED WITH LETTER OR ENDORSEMENT DATED ——, 194

PLATE III-23

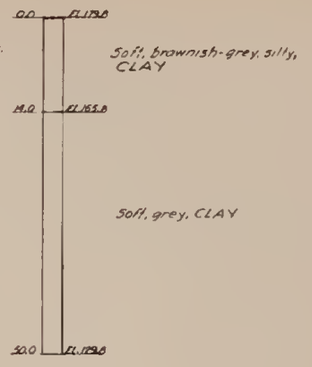
D1610



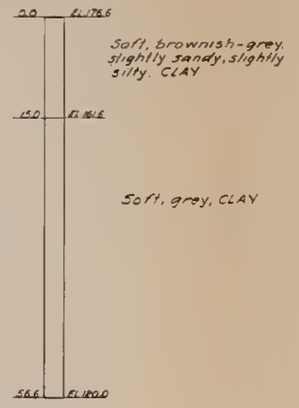
D-1611


0.0 EL 732
Soft, variable brown to grey, slightly sandy, slightly silty CLAY
18.6 EL 1612
Soft, grey, CLAY
44.0 EL 1152
Soft, greyish-black slightly silty, slightly gravelly, CLAY
73.9 EL 1053
76.4 EL 1049
Compact, grey, slightly gravelly, silty SAND

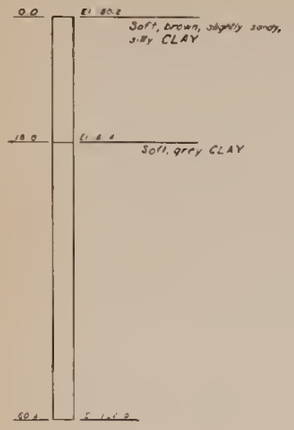
D-1612



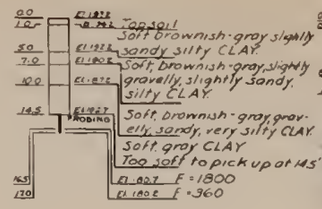
D-1613



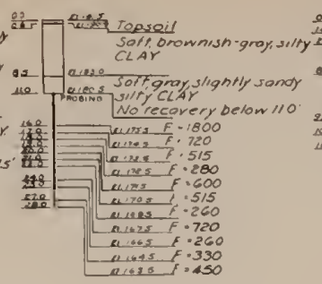
D-1614



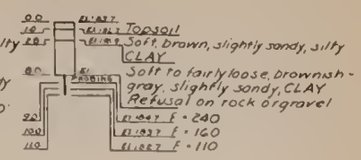
T-1615a


0.0 EL 1832
1.0 Topsoil
5.0 EL 1827
Soft brownish-gray slightly sandy silty CLAY
7.0 EL 1805
Soft, brownish-gray, slightly gravelly, slightly sandy, silty CLAY
10.0 EL 1782
Soft brownish-gray gravelly, sandy, very silty CLAY
14.5 EL 1767 PROBING
Soft gray CLAY
Too soft to pick up at 14.5'
16.5 EL 1627 F = 1800
17.0 EL 1805 F = 360

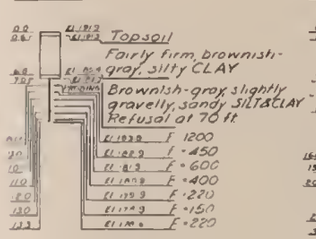
T-1616a



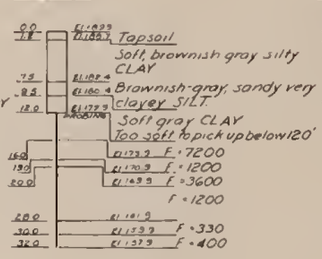
T-1617a


0.0 EL 1837
1.6 Topsoil
2.8 EL 1825
Soft, brown, slightly sandy, silty CLAY
6.0 EL PROBING
Soft to fairly loose, brownish-gray, slightly sandy, CLAY
Refusal on rock or gravel
9.0 EL 1807 F = 240
10.0 EL 1827 F = 160
11.0 EL 1827 F = 110

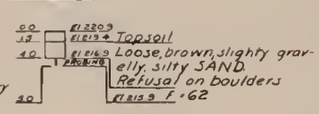
T-1618a


0.0 EL 1812
0.8 EL 1803
Topsoil
Fairly firm, brownish-gray, silty CLAY
6.8 EL 1797
7.0 EL 1795 PROBING
Brownish-gray, slightly gravelly, sandy SILT & CLAY
Refusal at 7.0 ft
EL 1793 F 1200
EL 1789 F = 450
EL 1783 F = 600
EL 1769 F = 400
EL 1759 F = 220
EL 1749 F = 150
EL 1740 F = 220

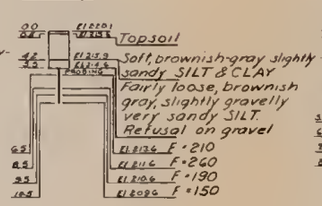
T-1619a


0.0 EL 1829
1.8 EL 1810
Topsoil
Soft, brownish gray silty CLAY
7.5 EL 1804
8.6 EL 1800
Brownish-gray, sandy very clayey SILT
12.0 EL 1779 PROBING
Soft gray CLAY
Too soft to pick up below 12.0'
16.0 EL 1773 F = 7200
19.0 EL 1770 F = 1200
20.0 EL 1769 F = 3600
F = 1200
28.0 EL 1751 F = 330
30.0 EL 1739 F = 400
32.0 EL 1719

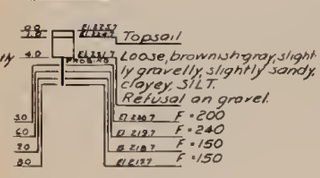
T-1620a



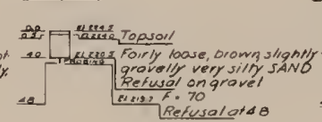
T-1621a


0.0 EL 2201
1.8 EL 1801
Topsoil
4.2 EL 1797
4.5 EL 1794 PROBING
Soft, brownish-gray slightly sandy SILT & CLAY
Fairly loose, brownish gray, slightly gravelly very sandy SILT
Refusal on gravel
6.2 EL 1776 F = 210
8.5 EL 1746 F = 260
9.5 EL 1706 F = 190
10.4 EL 2096 F = 150

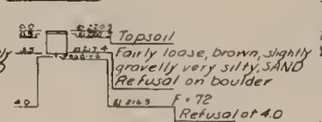
T-1622a


0.0 EL 1837
1.8 EL 1827
Topsoil
4.0 EL 1814 PROBING
Loose, brownish-gray, slightly gravelly, slightly sandy, clayey SILT
Refusal on gravel
EL 2067 F = 200
EL 2137 F = 240
EL 2187 F = 150
EL 2137 F = 150

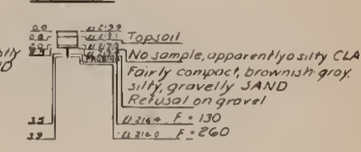
T-1623a



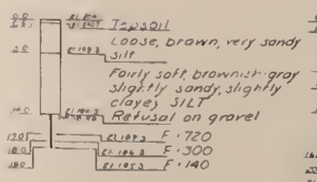
T-1624a



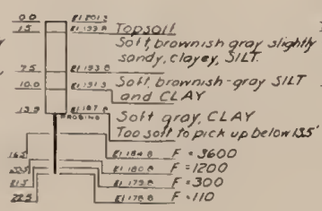
T-1625a


0.0 EL 1838
Topsoil
No sample, apparently a silty CLAY
2.0 EL 1836
Fairly compact, brownish gray, silty, gravelly SAND
Refusal on gravel
EL 2146 F = 130
EL 2160 F = 260

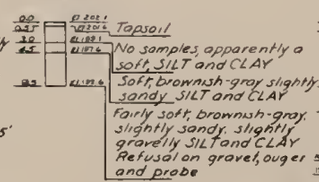
T-1626a


0.0 EL 1917
2.3 EL 1897
Topsoil
Loose, brown, very sandy silt
2.8 EL 1893 PROBING
Fairly soft, brownish-gray slightly sandy, slightly clayey SILT
Refusal on gravel
EL 1893 F = 720
EL 1883 F = 300
EL 1853 F = 140

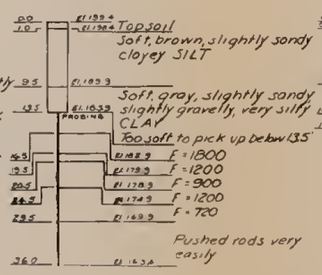
T-1627a


0.0 EL 1913
1.5 EL 1898
Topsoil
Soft, brownish gray, slightly sandy, clayey, SILT
7.5 EL 1883
10.0 EL 1873 PROBING
Soft, brownish-gray SILT and CLAY
13.9 EL 1857
Soft gray, CLAY
Too soft to pick up below 13.5'
16.2 EL 1840 F = 3600
20.0 EL 1800 F = 1200
21.5 EL 1790 F = 300
22.5 EL 1780 F = 110

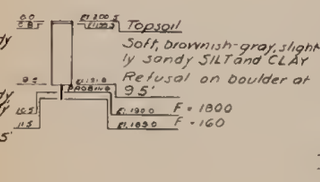
T-1628a


0.0 EL 2001
0.3 EL 2000
Topsoil
3.0 EL 1881
4.5 EL 1876
No samples, apparently a soft, SILT and CLAY
8.3 EL 1796
Soft, brownish-gray slightly sandy SILT and CLAY
Fairly soft, brownish-gray, slightly gravelly SILT and CLAY
Refusal on gravel, auger and probe

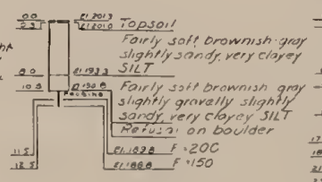
T-1629a


0.0 EL 1994
1.0 EL 1984
Topsoil
Soft, brown, slightly sandy clayey SILT
9.5 EL 1893
12.5 EL 1853 PROBING
Soft, gray, slightly sandy slightly gravelly, very silty CLAY
Too soft to pick up below 13.5'
16.5 EL 1818.9 F = 1800
17.5 EL 1783.9 F = 1200
20.5 EL 1738.9 F = 900
22.2 EL 1749 F = 1200
23.5 EL 1689.9 F = 720
Pushed rods very easily
26.0 EL 1663.4

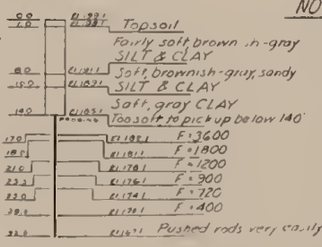
T-1630a


0.0 EL 2006.5
0.8 EL 2005.7
Topsoil
Soft, brownish-gray, slightly sandy SILT and CLAY
9.5 EL 1918 PROBING
Refusal on boulder at 9.5'
EL 1900 F = 1800
EL 1890 F = 160

T-1631a


0.0 EL 2013
2.3 EL 2010.8
Topsoil
Fairly soft, brownish-gray slightly sandy, very clayey SILT
10.3 EL 1938 PROBING
Fairly soft brownish gray slightly gravelly slightly sandy, very clayey SILT
Refusal on boulder
EL 1828 F = 200
EL 1888 F = 150

T-1632a


0.0 EL 2021
1.0 EL 2020
Topsoil
Fairly soft, brownish-gray SILT & CLAY
6.0 EL 1981
9.0 EL 1971
Soft, brownish-gray, sandy SILT & CLAY
14.0 EL 1951
Soft, gray CLAY
Too soft to pick up below 14.0'
17.0 EL 1921 F = 3600
18.5 EL 1911 F = 1800
21.0 EL 1891 F = 1200
23.2 EL 1876 F = 900
23.0 EL 1874 F = 720
28.0 EL 1861 F = 400
32.0 EL 1821 Pushed rods very easily

NOTES:

Analyses of overburden are based on dry samples.

Elevations are based on USC&GS datum M.S.L. 1912 adj.

Holes numbered greater than D1500 drilled in March 1942.

T-- - - denotes 5" diameter hand auger holes terminating at refusal or no recovery and extended by hand probing. Probing made with ¾" rod driven with 14 lb. sledge. 4.00 denotes rate of probing penetration in feet per hour.

See sheet File No. 4-CA-714 for descriptive terms.

TRAVERSE TRIANGULATION COORDINATES

STA. NO.	NORTH	EAST	STA. NO.	NORTH	EAST
D1610	1,815,[illegible]76	385,9[illegible]	T1622	1,814,932.58	365,128.39
D1611	1,815,[illegible]10	386,3[illegible]	T1623a	1,814,748.8	363,549.99
D1612	1,815,[illegible]	386,5[illegible]	T1624	1,814,360.20	363,693.72
D1613	1,815,4[illegible]	386,5[illegible]	T1525	1,814,248.8	363,643.85
D1614	1,815,[illegible]74	387,363.3	T1626	1,814,850.3[illegible]	367,288.00
T1615a	1,816,102.[illegible]	374,574.5[illegible]	T1627	1,814,977.66	361,624.28
T1616a	1,816,365.[illegible]	374,598.01	T1628	1,815,012.43	362,603.28
T1617a	1,816,802.[illegible]	377,296.6[illegible]	T1629	1,814,994.90	368,018.58
T1618a	1,816,853.[illegible]	377,507.4	T1630	1,815,212.8	367,981.4[illegible]
T1619a	1,815,903.[illegible]	377,888.11	T1631	1,815,481.1[illegible]	368,339.51
T1620a	1,814,411.[illegible]	364,396.6[illegible]	T1632	1,815,531.6	368,535.67
T1621a	1,814,560.[illegible]	364,777.7[illegible]			

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION EXPLORATION NO. 10

IN SHEETS | SHEET NO. | SCALE: 1" = 10Ft

U.S. ENGINEER OFFICE, MASSENA, N.Y. FEBRUARY, 1942

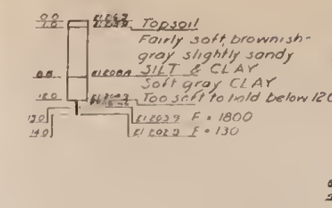
SUBMITTED: R.M. Hanna, ENGINEER

RECOMMENDED: [illegible], CHIEF, U.S. CORPS OF ENGINEERS

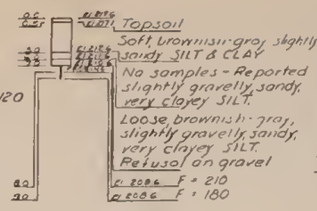
APPROVED: [illegible], COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: | CHECKED BY: | FILE NO. MC-A-2123 | TRANSMITTED WITH LETTER OF ENDORSEMENT DATED

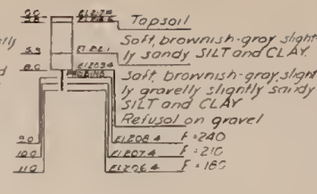
T-1633a



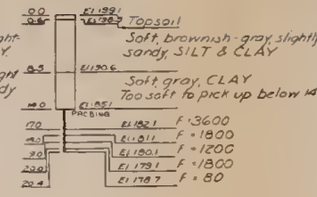
T-1634a


Topsoil
Soft, brownish-gray slightly sandy SILT & CLAY
No samples - Reported slightly gravelly sandy, very clayey SILT.
Loose, brownish-gray, slightly gravelly, sandy, very clayey SILT.
Refusal on gravel
F = 210
F = 180

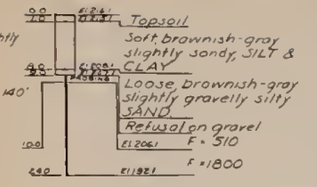
T-1635a


Topsoil
Soft, brownish-gray slightly sandy SILT and CLAY.
Soft, brownish-gray, slightly gravelly slightly sandy SILT and CLAY.
Refusal on gravel
F = 240
F = 210
F = 180

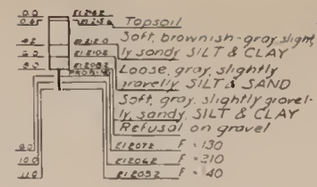
T-1636a



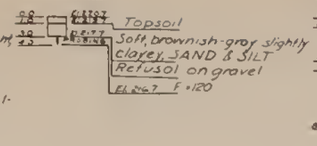
T-1637a



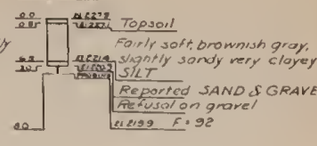
T-1638a


Topsoil
Soft, brownish-gray slightly sandy SILT & CLAY
Loose, gray, slightly gravelly SILT & SAND
Soft, gray, slightly gravelly sandy SILT & CLAY
Refusal on gravel
F = 130
F = 210
F = 40

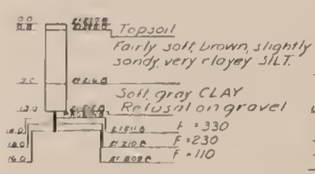
T-1639a



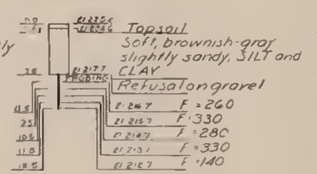
T-1640a



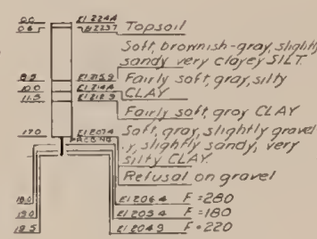
T-1641a



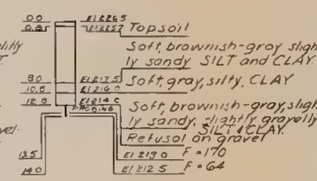
T-1642a



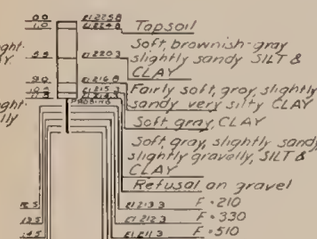
T-1643a


Topsoil
Soft, brownish-gray slightly sandy very clayey SILT.
Fairly soft, gray, silty CLAY
Fairly soft, gray CLAY
Soft, gray, slightly gravelly, slightly silty CLAY
Refusal on gravel
F = 280
F = 180
F = 220

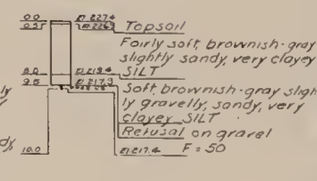
T-1644a


Topsoil
Soft, brownish-gray slightly sandy SILT and CLAY.
Soft gray, silty, CLAY
Soft, brownish-gray, slightly sandy, slightly gravelly SILT & CLAY.
Refusal on gravel
F = 170
F = 64

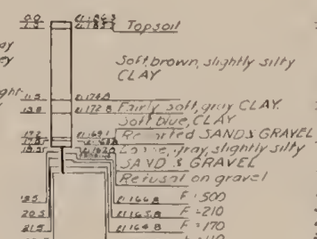
T-1645a


Topsoil
Soft, brownish-gray slightly sandy SILT & CLAY
Fairly soft, gray, slightly sandy very silty CLAY
Soft gray, CLAY
Soft gray, slightly sandy, slightly gravelly, SILT & CLAY
Refusal on gravel
F = 210
F = 330
F = 510
F = 280
F = 110

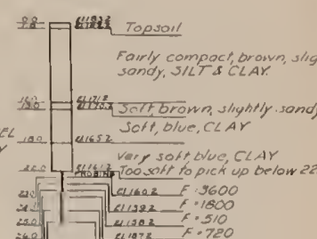
T-1646a


Topsoil
Fairly soft, brownish-gray slightly sandy, very clayey SILT
Soft, brownish-gray slightly gravelly, sandy, very clayey SILT
Refusal on gravel
F = 50

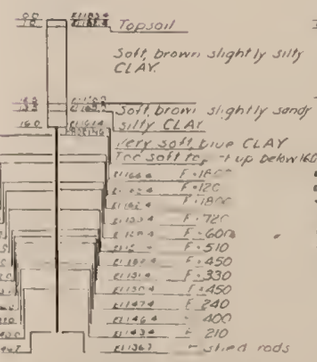
T-1647a



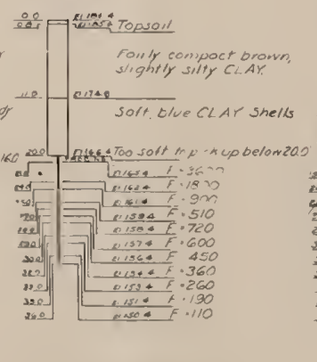
T-1648a



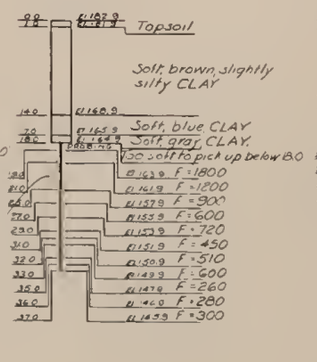
T-1649a



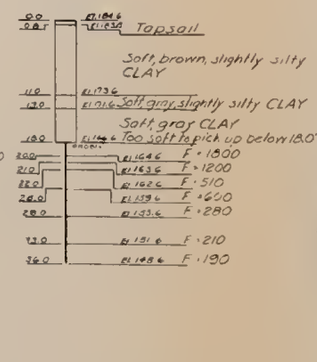
T-1650a



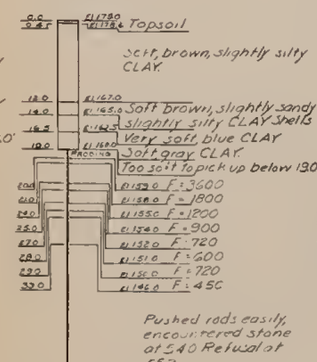
T-1651a



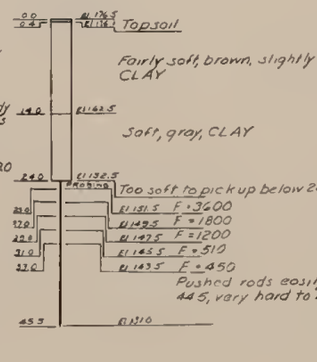
T-1652a



T-1653a



T-1654a


Topsoil
Fairly soft, brown, slightly silty, CLAY
Soft, gray, CLAY
Too soft to pick up below 24.0
F = 3600
F = 1800
F = 1200
F = 510
F = 450
Pushed rods easily from 330 to 445, very hard to 455, no refusal

TRANSVERSE MERCATOR COORDINATES

HOLE-NO.	NORTH	EAST	HOLE-NO.	NORTH	EAST
T-1633a	1,814,557.64	360,946.50	T-1644a	1,814,926.46	359,861.18
T-1634a	1,814,205.69	360,595.20	T-1645a	1,814,616.26	359,183.57
T-1635a	1,814,009.99	361,196.99	T-1646a	1,815,048.96	359,273.61
T-1636a	1,814,351.85	360,270.31	T-1647a	1,814,208.22	383,045.83
T-1637a	1,814,248.78	360,945.00	T-1648a	1,814,661.69	383,642.64
T-1638a	1,814,259.19	360,847.77	T-1649a	1,814,767.64	384,234.08
T-1639a	1,814,584.48	351,035.50	T-1650a	1,814,198.34	384,159.72
T-1640a	1,814,906.05	359,959.07	T-1651a	1,817,872.01	384,874.82
T-1641a	1,814,587.70	359,913.95	T-1652a	1,816,299.29	384,751.17
T-1642a	1,814,452.53	359,966.75	T-1653a	1,816,417.07	385,441.19
T-1643a	1,814,473.35	359,268.83	T-1654a	1,817,981.37	385,515.55

NOTES.

Analyses of overburden are based on dry samples.
Elevations are based on U.S.G.S. datum. M.C.L. 1912 adjustment.

Holes numbered greater than D1500 drilled with 2½" casing.
T----a denotes 3" diameter hand auger holes to refusal or no recovery and extended by hand probing. Probing made with ¾" rod driven with 14" sledge.
F:00 denotes rate of probing penetration in feet per hour.
See sheet File No. MC-A-1/4 for descriptive terms.

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION EXPLORATION NO. 11

IN SHEETS | SHEET NO. | SCALE: 1"=10 Ft

10 0 10 20

U.S. ENGINEER OFFICE, MASSENA, N.Y. FEBRUARY 5, 1942

SUBMITTED: R. M. Hamer, ENGINEER

RECOMMENDED: [illegible], ASST. ENGINEER

APPROVED: [illegible], CHIEF OF ENGINEERS, Colonel, Corps of Engineers, DISTRICT ENGINEER

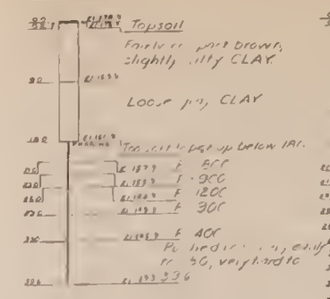
DRAWN BY: E.H.A. CHECKED BY: ---

FILE NO. MC-A-2/24

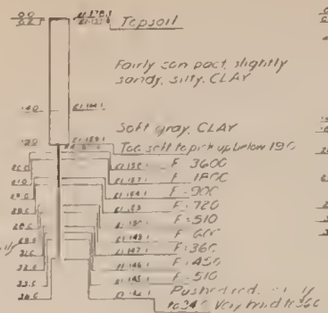
TRANSMITTED WITH LETTER OF INDORSEMENT DATED ---------- 194

PLATE III-25

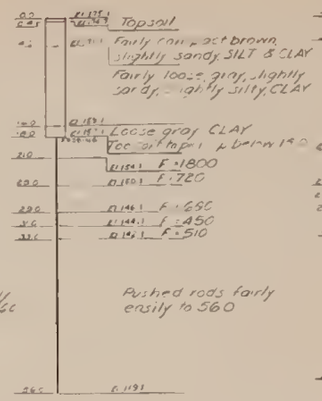
T-1655a


Topsoil
Fairly soft, brown, slightly silty CLAY
Loose gray CLAY
Too soft to pick up below 180'
Pushed rods fairly easily to 196'

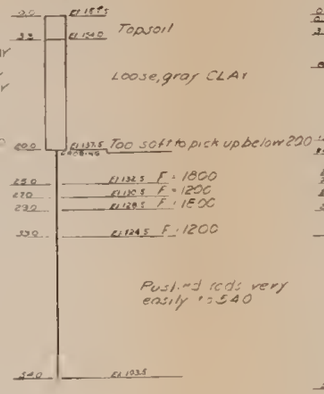
T-1656a


Topsoil
Fairly compact, slightly sandy, silty CLAY
Soft gray CLAY
Too soft to pick up below 190'
Pushed rods very easily to 345'

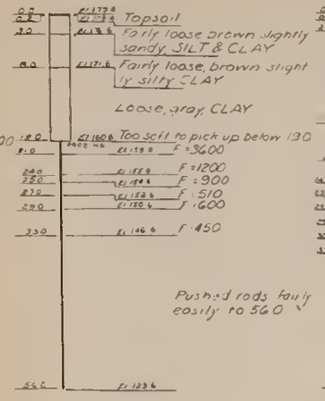
T-1657a


Topsoil
Fairly compact brown, slightly sandy, SILT & CLAY
Fairly loose, gray, slightly sandy, slightly silty CLAY
Loose gray CLAY
Too soft to pick up below 190'
Pushed rods fairly easily to 560'

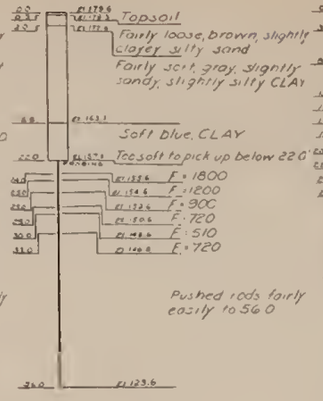
T-1658a



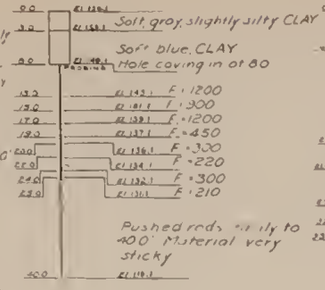
T-1659a


Topsoil
Fairly loose brown slightly sandy, SILT & CLAY
Fairly loose, brown slightly silty CLAY
Loose, gray CLAY
Too soft to pick up below 130'
Pushed rods fairly easily to 560'

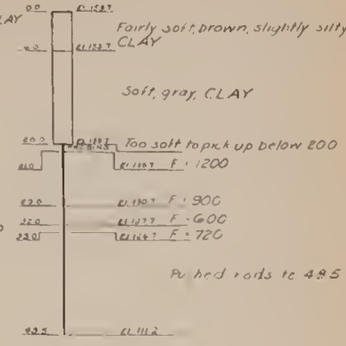
T-1660a


Topsoil
Fairly loose, brown, slightly clayey, silty sand
Fairly soft, gray, slightly sandy, slightly silty CLAY
Soft blue, CLAY
Too soft to pick up below 220'
Pushed rods fairly easily to 560'

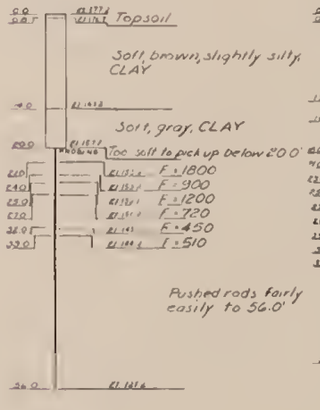
T-1661a



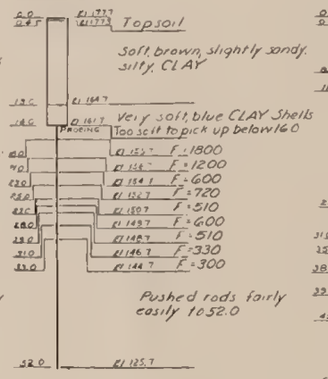
T-1662a



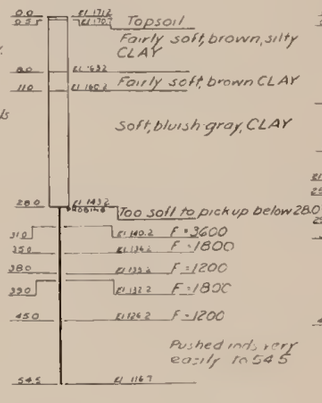
T-1663a



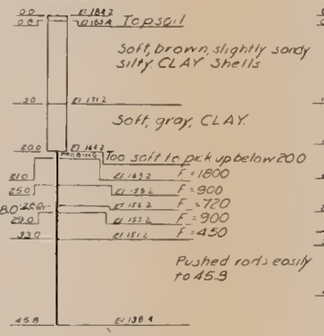
T-1664a


Topsoil
Soft, brown, slightly sandy, silty, CLAY
Very soft, blue CLAY Shells
Too soft to pick up below 160'
Pushed rods fairly easily to 52.0'

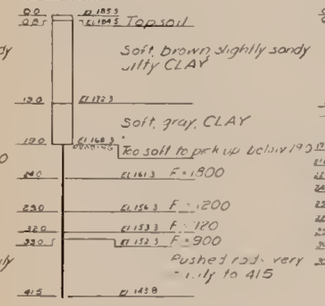
T-1665a


Topsoil
Fairly soft, brown, silty CLAY
Fairly soft brown CLAY
Soft, bluish gray, CLAY
Too soft to pick up below 280'
Pushed rods very easily to 545'

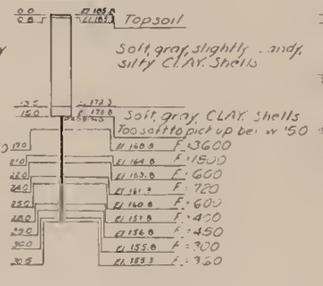
T-1666a


Topsoil
Soft, brown, slightly sandy silty CLAY Shells
Soft, gray, CLAY
Too soft to pick up below 200'
Pushed rods easily to 45.9'

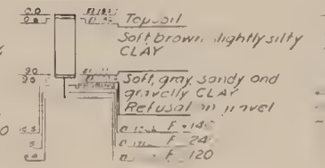
T-1667a



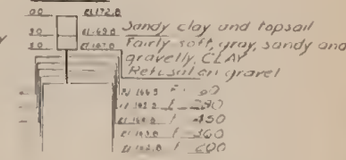
T-1668a



T-1669a



T-1670a



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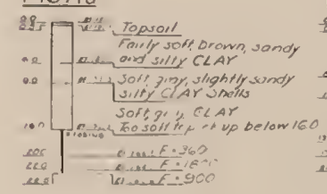
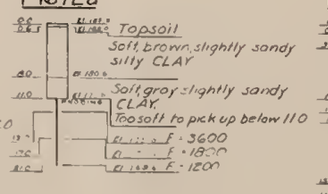
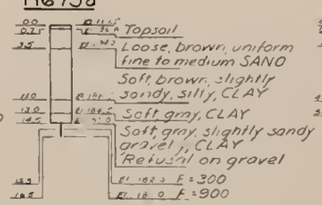

Topsoil
Fairly soft brown, sandy and silty CLAY
Soft, gray, slightly sandy silty CLAY Shells
Soft, gray CLAY
Too soft to pick up below 160'

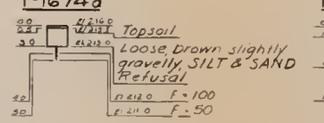
T-1672a



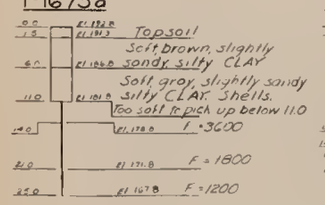
T1673a


Topsoil
Loose, brown, uniform fine to medium SAND
Soft, brown, slightly sandy, silty, CLAY
Soft, gray, CLAY
Soft, gray, slightly sandy gravel, CLAY
Refusal on gravel

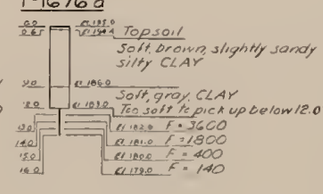
T-1674a



T-1675a



T-1676a



NOTES

Analyses of overburden are based on dry samples.
Elevations are based on U.S.G.S. datum M.S.L. 1912 adj.

Holes numbered greater than D1500 drilled with 2½" casing.
T---a denotes 5" diameter tailed auger holes to refusal on rock covered and extended by sand probing made with ¾" driver with 140 lb. hammer F=00 ft. rate of progress in feet per hour.
See sheet File No. MC-A-1/4 for location T-1655a

TRANSVERSE MERCATOR COORDINATES

HOLE NO.	NORTH	EAST	HOLE NO.	NORTH	EAST
T-1655a	1,818,518.02	386,032.54	T-1667a	1,817,980.49	364,196.50
T-1656a	1,818,082.32	386,167.02	T-1668a	1,817,879.54	363,605.46
T-1657a	1,818,183.27	386,698.44	T-1669a	1,817,795.42	362,112.58
T-1658a	1,818,210.18	386,856.16	T-1670a	1,817,711.30	362,619.71
T-1659a	1,818,618.97	386,624.06	T-1671a	1,817,105.60	379,071.03
T-1660a	1,818,719.91	387,215.93	T-1672a	1,817,021.65	378,479.58
T-1661a	1,818,603.09	387,737.97	T-1673a	1,816,701.81	376,705.94
T-1662a	1,818,502.06	387,252.71	T-1674a	1,816,499.91	375,532.35
T-1663a	1,818,431.18	386,661.26	T-1675a	1,816,298.01	374,339.46
T-1664a	1,818,300.17	386,069.81	T-1676a	1,816,197.06	373,748.01
T-1665a	1,818,199.82	385,478.37			
T-1666a	1,818,081.44	384,788.35			

ST LAWRENCE RIVER PROJECT
LONG SAULT CANAL
RECORD OF FOUNDATION EXPLORATION NO. 12

IN SHEETS SHEET NO. SCALE 1" = 50'

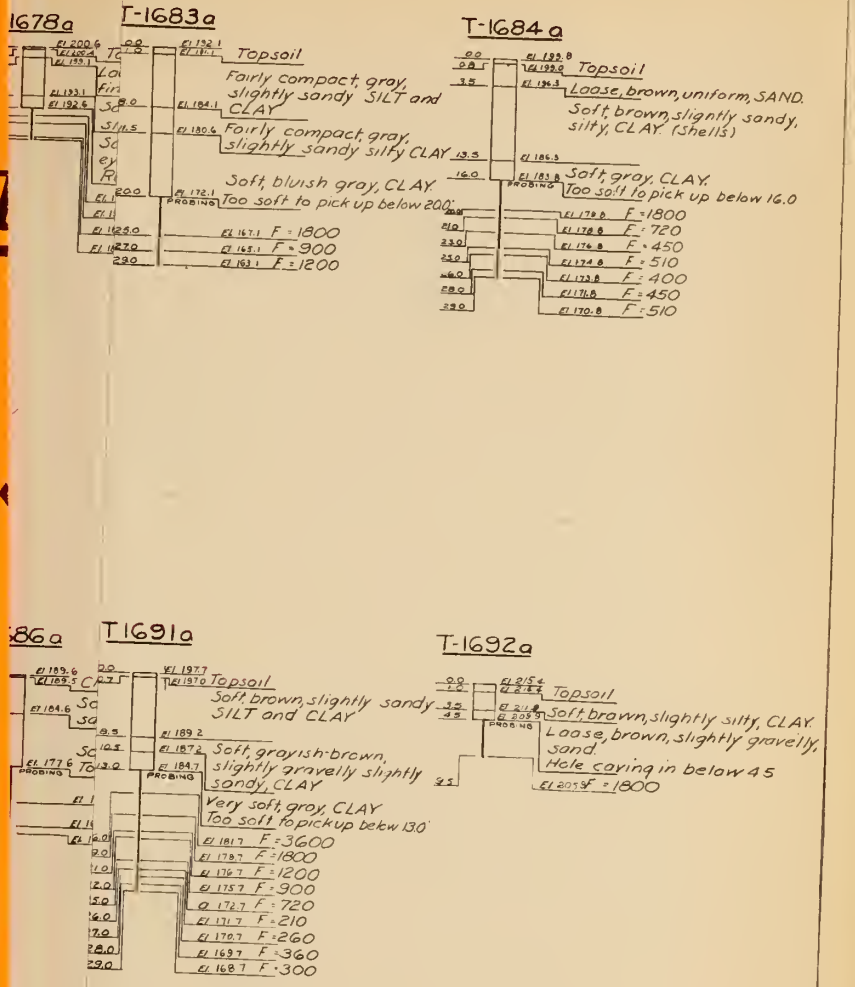
U.S. ENGINEER OFFICE MASSENA, N.Y. FEBRUARY 1942

SUBMITTED: R. M. Hanmer, ENGINEER
RECOMMENDED: [signature], LIEUT. COLONEL, CORPS OF ENGINEERS
APPROVED: [signature], FOR COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

GRADE OF DATA
CHECKED BY
MC-A-2/25
TRANSMITTED WITH LETTER OR ENDORSEMENT DATED

PLATE No. -26

Foldout Here



NOTES:

Analyses of overburden are based on dry samples
Elevations are based on U.S.C.S. datum M S L 1912 adj.

Holes numbered greater than D1500 drilled with 2½" casing
T-----a denotes 5" diameter hand auger hole to refusal or no recovery and extended by hand probing. Probing made with ¾" rod driven with 14# sledge.
F-00 denotes rate of probing penetration in feet per hour.
See sheet File No. MC-A-9/4 for descriptive terms.

TRANSVERSE MERCATOR COORDINATES

HOLE-NO	NORTH	EAST	HOLE-NO	NORTH
T1677a	1,815,096.11	373,155.56	T1688a	1,815,389.
T1678a	1,815,995.16	372,565.12	T1689a	1,815,312.7
T1679a	1,815,894.21	371,973.67	T1690a	1,815,095.
T1680a	1,815,798.31	371,411.79	T1691a	1,815,263.
T1681a	1,815,016.16	371,374.61	T1692a	1,814,576.
T1682a	1,815,692.31	370,790.78	T1693a	1,814,539.
T1683a	1,815,591.37	370,199.33	T1694a	1,814,376.
T1684a	1,815,803.22	370,162.15	T1695a	1,814,309.
T1685a	1,815,699.85	369,521.41	T 696a	1,814,301.
T1686a	1,815,482.00	369,558.59	T1697a	1,814,424.
T1687a	1,815,607.32	368,979.25	T1698a	1,814,465.

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION EXPLORATION NO 13

IN SHEETS SHEET NO. SCALE: 1" = 10 Ft

10 0 10 20

U.S. ENGINEER OFFICE, MASSENA, N.Y. FEBRUARY 1942

SUBMITTED: R. M. Hain, ENGINEER

RECOMMENDED: [signature], CAP. ENGR; [signature], LT. COL. CORPS OF ENGINEERS

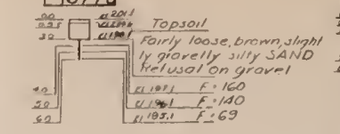
APPROVED: [signature], COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: CHECKED BY: R.M.

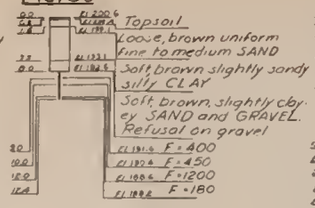
MC-A-2/26 FILE NO:

TRANSMITTED WITH LETTER OR INDORSEMENT DATED 194

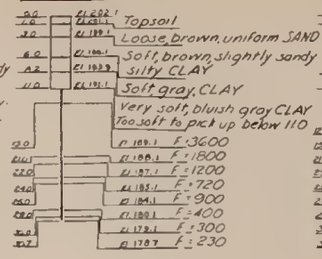
T-1677a



T-1678a


Topsoil
Loose, brown uniform fine to medium SAND
Soft, brown, slightly sandy silty CLAY
Soft, brown, slightly clayey SAND and GRAVEL
Refusal on gravel
F - 400
F - 450
F - 1200
F - 180

T-1679a



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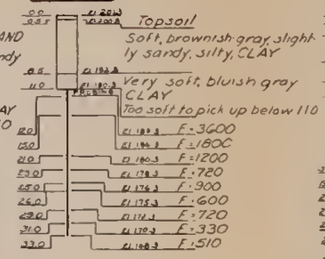
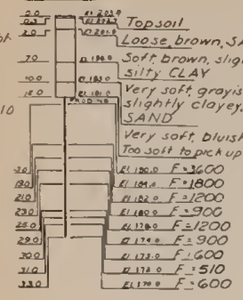
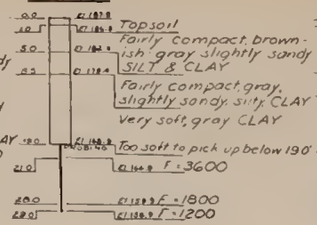


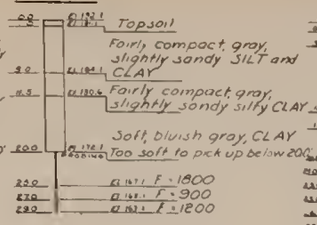
T-1681a



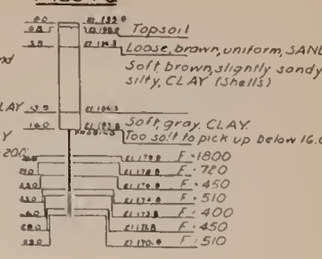
T-1682a


Topsoil
Fairly compact, brownish gray slightly sandy SILT & CLAY
Fairly compact, gray, slightly sandy, silty CLAY
Very soft, gray CLAY
Too soft to pick up below 190'
F - 3600
F - 1800
F - 1200

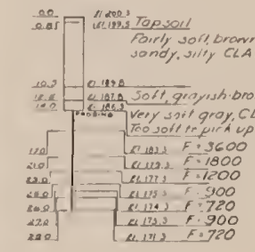
T-1683a


Topsoil
Fairly compact, gray, slightly sandy SILT and CLAY
Fairly compact, gray, slightly sandy silty CLAY
Soft, bluish gray, CLAY
Too soft to pick up below 200'
F - 1800
F - 900
F - 1200

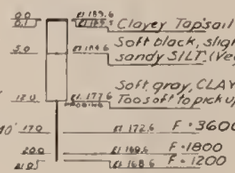
T-1684a



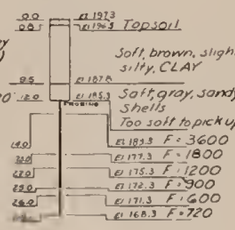
T-1685a



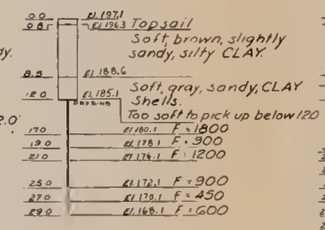
T-1686a


Clayey Topsoil
Soft black, slightly clayey sandy SILT (Vegetation)
Soft gray, CLAY
Too soft to pick up below 120'
F - 3600
F - 1800
F - 1200

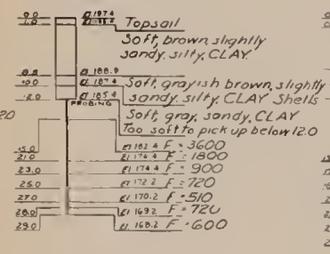
T-1687a



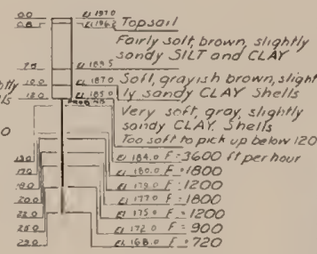
T-1688a



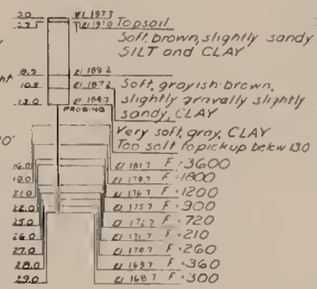
T-1689a



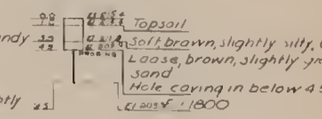
T-1690a


Topsoil
Fairly soft, brown, slightly sandy SILT and CLAY
Soft, grayish brown, slightly sandy CLAY Shells
Very soft, gray, slightly sandy CLAY. Shells
Too soft to pick up below 120'
F - 3600 ft per hour
F - 1800
F - 1200
F - 1800
F - 1200
F - 900
F - 720

T-1691a



T-1692a



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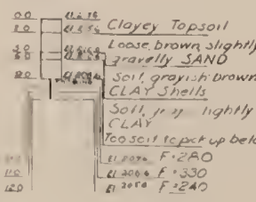
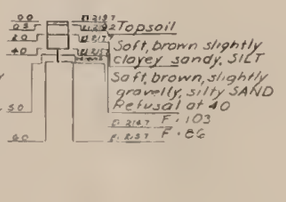

Clayey Topsoil
Loose brown slightly gravelly SAND
Soft, grayish brown, sandy CLAY Shells
Soft, gray, slightly sandy CLAY
Too soft to pick up below 90
F - 240
F - 330
F - 240

T-1694a



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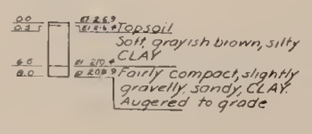

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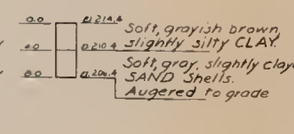

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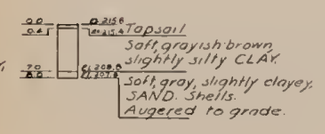

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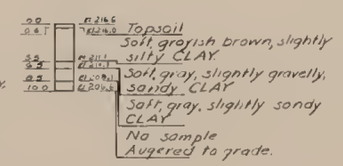


NOTES:

Analyses of overburden are based on dry samples.
Elevations are based on U.S.G.S. datum M.S.L. 1912 adj.

Holes numbered greater than 11500 drilled with 4½" casing.
T ---- denotes 5" diameter hand auger hole refusal or no recovery and extended by hand probing. Probing made with ¾" rod driven with 14# sledge.
F-00 denotes rate of probing penetration in feet per hour.
See sheet Field No. MC-A-9/4 for descriptive terms.

TRAIN. RSE MERCATOR COORDINATES

HOLE NO	NORTH	EAST	HOLE NO	NORTH	EAST
T-1677a	1,816,056	373,155.56	T-1688a	1,815,389.47	369,016.43
T-1678a	1,815,995.16	372,565.12	T-1689a	1,815,313.76	368,372.85
T-1679a	1,815,894.21	371,973.67	T-1690a	1,815,695.91	368,210.03
T-1680a	1,815,798.31	371,411.79	T-1691a	1,815,263.28	368,177.13
T-1681a	1,815,716.16	371,314.61	T-1692a	1,814,876.51	364,765.15
T-1682a	1,815,492.31	370,790.76	T-1693a	1,814,539.61	364,032.42
T-1683a	1,815,391.37	370,190.33	T-1694a	1,814,376.61	363,086.25
T-1684a	1,815,362.22	370,162.15	T-1695a	1,814,309.31	362,687.95
T-1685a	1,815,699.83	369,521.41	T-1696a	1,814,301.80	361,773.24
T-1686a	1,815,451.00	369,558.59	T-1697a	1,814,424.30	361,186.53
T-1687a	1,815,607.32	368,979.25	T-1698a	1,814,465.13	360,990.78

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION EXPLORATION NO 13

IN SHEETS | SHEET NO | SCALE: 1 inch = 10 ft

U.S. ENGINEER OFFICE, MASSENA, N.Y. FEBRUARY 1942

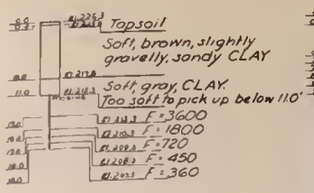
SUBMITTED: R. M. Hunt, ENGINEER

RECOMMENDED: [illegible], RESIDENT ENGINEER; C. Sutton, LT. COL., CORPS OF ENGINEERS

APPROVED: [illegible], COL., CORPS OF ENGINEERS, DIST. ENGINEER

DRAWN BY: | CHECKED BY: RM | MC-A-2/26 FILE NO: | TRANSMITTED WITH LETTER OF ENDORSEMENT DATED ____ 194

T-1699a



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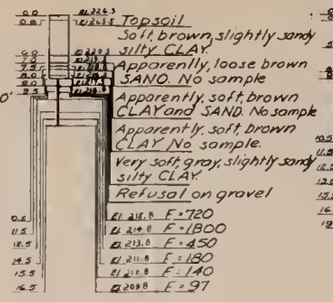

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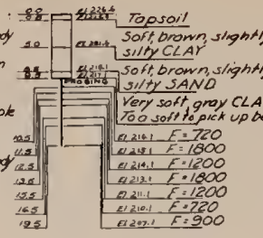

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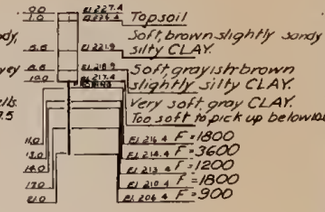

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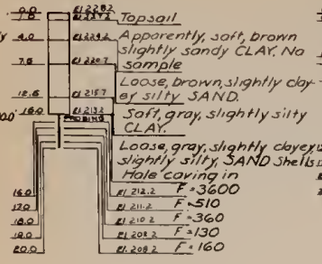

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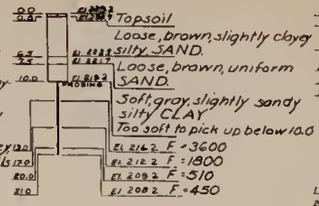

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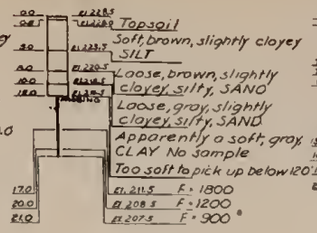

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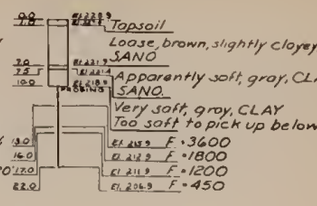
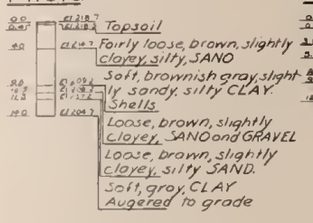
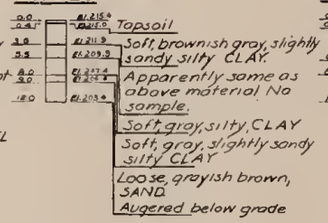


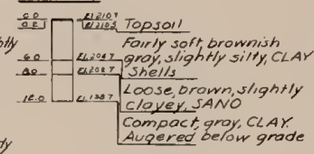
T-1707a


Topsoil
Fairly loose, brown, slightly clayey, silty, SAND
Soft, brownish gray, slightly sandy, silty CLAY.
Shells
Loose, brown, slightly clayey, SAND and GRAVEL
Loose, brown, slightly clayey, silty SAND.
Soft, gray, CLAY
Augered to grade

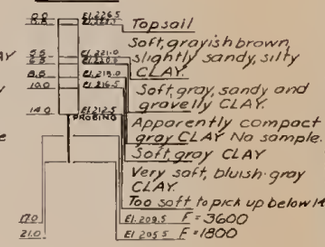
T-1708a


Topsoil
Soft, brownish gray, slightly sandy silty CLAY.
Apparently same as above material No sample.
Soft gray, silty, CLAY
Soft, gray, slightly sandy silty CLAY
Loose, grayish brown, SAND.
Augered below grade

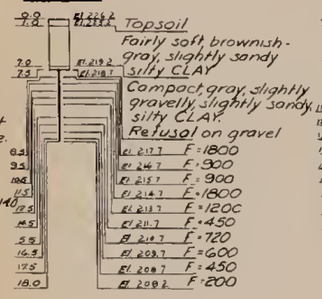
T-1709a



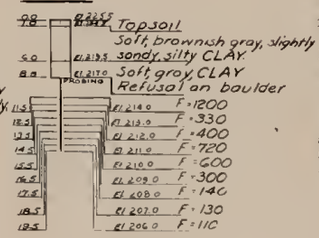
T-1710a



T-1711a



T-1712a



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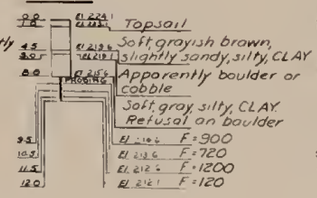

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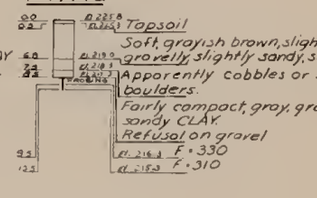

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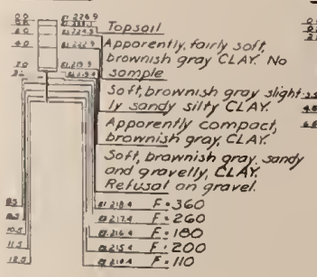
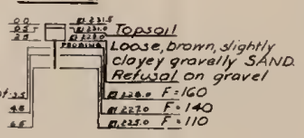


T-1716a



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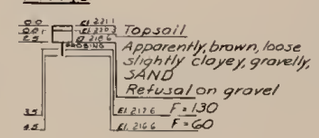

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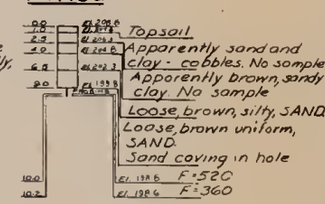
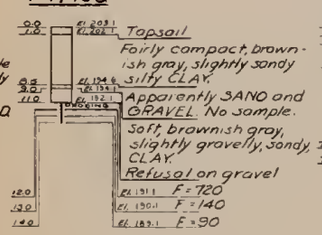


T-1719a



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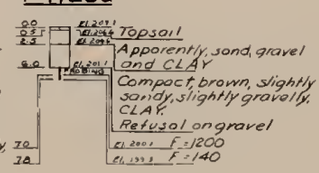


NOTES:

Analyses of overburden are based on dry samples
Elevations are base on U.S.G.S. datum MSL. 1912 adjustment

Holes numbered greater than D1500 drilled with 2½" casing.
T----a denotes 5" diameter hand auger holes to refusal or no recovery and extended by hand probing. Probing made with ¾" rod driven with 14# sledge.
F=00 denotes rate of probing penetration in feet per hour.
See sheet File No. MC-A 7/4 for descriptive terms.

TRANSVERSE MERCATOR COORDINATES

HOLE-NO	NORTH	EAST	HOLE-NO	NORTH	EAST
T1699a	1,814,955.10	358,641.33	T1710a	1,815,110.20	358,980.13
T1700a	1,814,738.75	358,596.21	T1711a	1,814,893.85	358,935.01
T1701a	1,815,077.59	358,053.97	T1712a	1,814,677.50	358,882.89
T1702a	1,815,293.94	358,099.09	T1713a	1,814,344.80	359,526.20
T1703a	1,815,200.09	357,486.61	T1714a	1,814,761.15	359,571.32
T1704a	1,815,322.58	356,879.24	T1715a	1,814,917.50	359,616.44
T1705a	1,815,445.07	356,291.88	T1716a	1,814,678.45	360,207.63
T1706a	1,815,661.42	356,337.00	T1717a	1,814,506.16	363,841.28
T1707a	1,815,700.21	356,151.00	T1718a	1,814,826.71	367,032.84
T1708a	1,815,470.80	356,168.53	T1719a	1,815,179.16	367,784.25
T1709a	1,815,283.85	355,982.45	T1720a	1,815,464.31	368,141.37

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION EXPLORATION NO. 14

IN SHEETS SHEET NO. SCALE 1"=10 Ft

U.S. ENGINEER OFFICE, MASSENA, NEW YORK FEBRUARY 1942

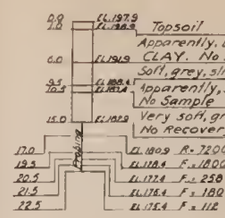
SUBMITTED R.M. Hames ENGINEER

RECOMMENDED [illegible] HEAD ENGR. [illegible] LT. COL. CORPS OF ENGINEERS

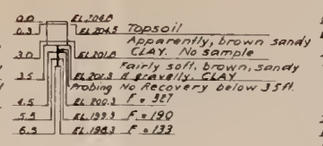
APPROVED [illegible] COL. CORPS OF ENGINEERS DISTRICT ENGINEER

DRAWN BY E.S.G. CHECKED BY M.H. FILE NO: MC-A-2/27 TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 194

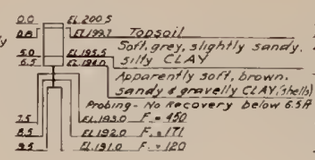
T-1721a


0.0 EL 197.9
0.8 EL 196.9 Topsoil
Apparently, brownish grey, CLAY. No Sample
6.0 EL 191.9
9.5 EL 188.4 EL 187.4
Apparently, soft, sandy CLAY No Sample
15.0 EL 182.9
Very soft, grey, CLAY. No Recovery below 15 ft.
Probing
17.0 EL 180.9 R = 7200
18.5 EL 178.4 F = 1800
20.5 EL 177.4 F = 250
21.5 EL 176.4 F = 180
22.5 EL 175.4 F = 112

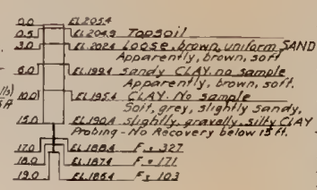
T-1722a


0.0 EL 204.8
0.3 EL 204.5 Topsoil
Apparently, brown sandy CLAY. No sample
3.0 EL 201.8
Fairly soft, brown, sandy & gravelly CLAY
3.5 EL 201.3
Probing No Recovery below 3.5 ft.
4.5 EL 200.3 F = 327
5.5 EL 199.3 F = 190
6.5 EL 198.3 F = 133

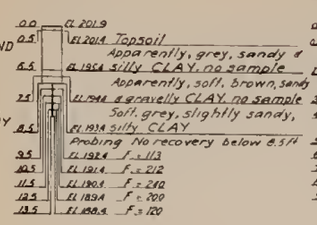
T-1723a


0.0 EL 200.5
0.8 EL 199.7 Topsoil
Soft, grey, slightly sandy, silty CLAY
5.0 EL 195.5
6.5 EL 194.0
Apparently soft, brown, sandy & gravelly CLAY (shells)
Probing - No Recovery below 6.5 ft.
7.5 EL 193.0 F = 450
8.5 EL 192.0 F = 171
9.5 EL 191.0 F = 120

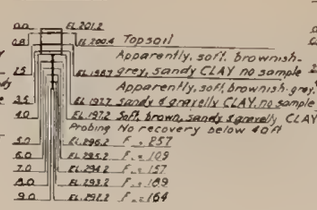
T-1724a


0.0 EL 205.4
0.5 EL 204.9 Topsoil
3.0 EL 202.4 Loose, brown, uniform SAND
Apparently, brown, soft.
6.0 EL 199.4 sandy CLAY. no sample
Apparently, brown, soft.
10.0 EL 195.4 CLAY. No sample
Soft, grey, slightly sandy,
15.0 EL 190.4 slightly gravelly, silty CLAY
Probing - No Recovery below 15 ft.
17.0 EL 188.4 F = 327
18.0 EL 187.4 F = 171
19.0 EL 186.4 F = 103

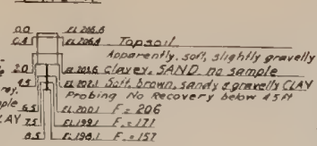
T-1725a


0.0 EL 201.9
0.5 EL 201.4 Topsoil
Apparently, grey, sandy & CLAY
6.5 EL 195.4 silty CLAY. no sample
Apparently, soft, brown, sandy
7.5 EL 194.4 & gravelly CLAY no sample
Soft, grey, slightly sandy,
8.5 EL 193.4 silty CLAY
Probing No recovery below 8.5 ft
9.5 EL 192.4 F = 113
10.5 EL 191.4 F = 212
11.5 EL 190.4 F = 240
12.5 EL 189.4 F = 200
13.5 EL 188.4 F = 120

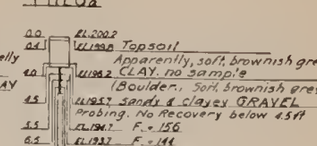
T-1726a


0.0 EL 201.2
0.8 EL 200.4 Topsoil
Apparently, soft, brownish-
1.5 EL 199.7 grey, sandy CLAY no sample
Apparently, soft, brownish grey,
2.5 EL 198.7 sandy & gravelly CLAY. no sample
4.0 EL 197.2 Soft, brown, sandy & gravelly CLAY
Probing No recovery below 4.0 ft
5.0 EL 196.2 F = 857
6.0 EL 195.2 F = 109
7.0 EL 194.2 F = 157
8.0 EL 193.2 F = 189
9.0 EL 192.2 F = 164

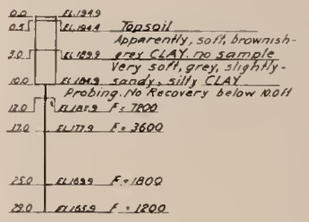
T-1727a


0.0 EL 206.8
0.8 EL 206.0 Topsoil
Apparently, soft, slightly gravelly
2.0 EL 204.8 clayey SAND. no sample
Soft, brown, sandy & gravelly CLAY
Probing No Recovery below 4.5 ft
6.5 EL 200.1 F = 206
7.5 EL 199.1 F = 171
8.5 EL 198.1 F = 157

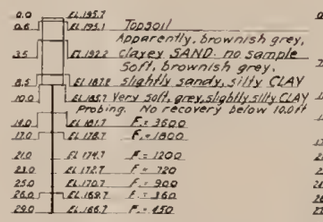
T-1728a


0.0 EL 200.2
0.4 EL 199.8 Topsoil
Apparently, soft, brownish grey,
4.0 EL 196.2 CLAY. no sample
(Boulders. Soft, brownish grey,
4.5 EL 195.7 sandy & clayey GRAVEL
Probing. No Recovery below 4.5 ft
5.5 EL 194.7 F = 156
6.5 EL 193.7 F = 144
7.5 EL 192.7 F = 180
8.5 EL 191.7 F = 200

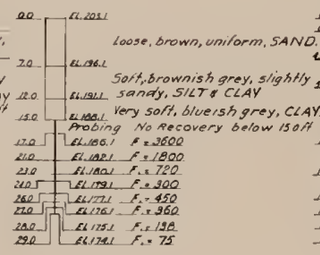
T-1729a


0.0 EL 194.9
0.5 EL 194.4 Topsoil
Apparently, soft, brownish-
3.0 EL 192.9 grey CLAY no sample
Very soft, grey, slightly-
10.0 EL 185.9 sandy, silty CLAY
Probing. No Recovery below 10.0 ft
12.0 EL 183.9 F = 7200
13.0 EL 177.9 F = 3600
25.0 EL 163.9 F = 1800
29.0 EL 159.9 F = 1200

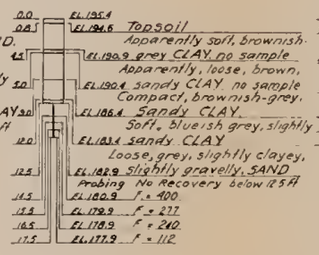
T-1730a


0.0 EL 195.7
0.6 EL 195.1 Topsoil
Apparently, brownish grey,
3.5 EL 192.2 clayey SAND. no sample
Soft, brownish grey,
8.5 EL 187.2 slightly sandy, silty CLAY
10.0 EL 185.7 Very soft, grey, slightly silty CLAY
Probing. No recovery below 10.0 ft
14.0 EL 181.7 F = 3600
17.0 EL 178.7 F = 1800
21.0 EL 174.7 F = 1200
23.0 EL 172.7 F = 720
25.0 EL 170.7 F = 900
26.0 EL 169.7 F = 360
29.0 EL 166.7 F = 450

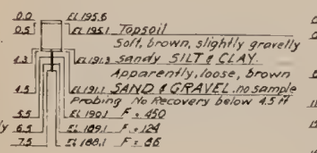
T-1731a


0.0 EL 203.1
Loose, brown, uniform, SAND.
7.0 EL 196.1
Soft, brownish grey, slightly
12.0 EL 191.1 sandy, SILT & CLAY
Very soft, blueish grey, CLAY
15.0 EL 188.1
Probing No Recovery below 15.0 ft
17.0 EL 186.1 F = 3600
21.0 EL 182.1 F = 1800
23.0 EL 180.1 F = 720
24.0 EL 179.1 F = 900
26.0 EL 177.1 F = 450
27.0 EL 176.1 F = 360
28.0 EL 175.1 F = 150
29.0 EL 174.1 F = 75

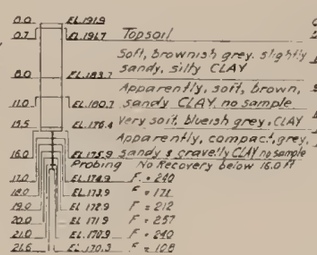
T-1732a


0.0 EL 195.4
0.8 EL 194.6 Topsoil
Apparently soft, brownish-
4.5 EL 190.9 grey CLAY. no sample
5.0 EL 190.4 sandy CLAY. no sample
Apparently, loose, brown,
Compact, brownish-grey,
12.0 EL 183.4 sandy CLAY
Soft, blueish grey, slightly
12.5 EL 182.9 Slightly gravelly, SAND
Loose, grey, slightly clayey,
Probing No Recovery below 12.5 ft
16.5 EL 178.9 F = 900
17.5 EL 177.9 F = 240
18.5 EL 176.9 F = 112

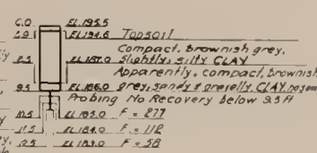
T-1733a


0.0 EL 195.6
0.5 EL 195.1 Topsoil
Soft, brown, slightly gravelly
4.3 EL 191.3 sandy SILT & CLAY.
Apparently, loose, brown
4.5 EL 191.1 SAND & GRAVEL. no sample
Probing No Recovery below 4.5 ft
5.5 EL 190.1 F = 450
6.5 EL 189.1 F = 124
7.5 EL 188.1 F = 66

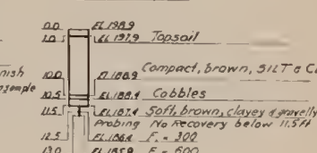
T-1734a


0.0 EL 201.9
0.7 EL 201.2 Topsoil
Soft, brownish grey, slightly
2.0 EL 199.7 sandy, silty CLAY
Apparently, soft, brown,
11.0 EL 190.7 sandy CLAY. no sample
13.5 EL 188.2 Very soft, blueish grey, CLAY
Apparently, compact, grey,
16.0 EL 185.9 sandy & gravelly CLAY no sample
Probing No Recovery below 16.0 ft
17.0 EL 184.9 F = 240
18.0 EL 183.9 F = 171
19.0 EL 182.9 F = 212
20.0 EL 181.9 F = 257
21.0 EL 180.9 F = 240
21.6 EL 180.3 F = 108

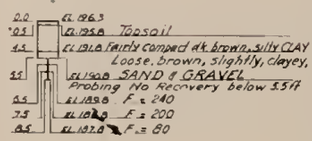
T-1735a


0.0 EL 195.5
0.9 EL 194.6 Topsoil
Compact, brownish grey,
2.5 EL 192.0 slightly silty CLAY
Apparently, compact, brownish
9.5 EL 185.0 grey, sandy & gravelly CLAY no sample
Probing No Recovery below 9.5 ft
10.5 EL 184.0 F = 277
11.5 EL 183.0 F = 118
12.5 EL 182.0 F = 58

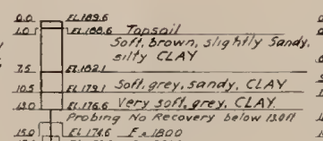
T-1736a


0.0 EL 198.9
1.0 EL 197.9 Topsoil
Compact, brown, SILT & CLAY
10.0 EL 188.9
10.5 EL 188.4 Cobbles
11.5 EL 187.4 Soft, brown, clayey & gravelly SAND
Probing No Recovery below 11.5 ft
12.5 EL 186.4 F = 300
13.0 EL 185.9 F = 600

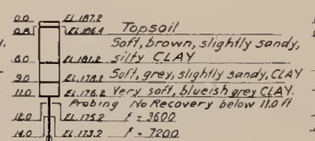
T-1737a


0.0 EL 196.3
0.5 EL 195.8 Topsoil
4.5 EL 191.8 Fairly Compact dk. brown, silty CLAY
Loose, brown, slightly, clayey,
5.5 EL 190.8 SAND & GRAVEL
Probing No Recovery below 5.5 ft
6.5 EL 189.8 F = 240
7.5 EL 188.8 F = 200
8.5 EL 187.8 F = 80

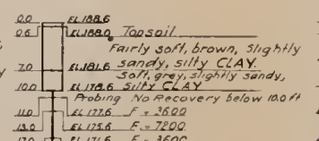
T-1738a


0.0 EL 189.6
1.0 EL 188.6 Topsoil
Soft, brown, slightly Sandy, silty CLAY
7.5 EL 182.1
10.5 EL 179.1 Soft, grey, sandy, CLAY
13.0 EL 176.6 Very soft, grey, CLAY
Probing No Recovery below 13.0 ft
15.0 EL 174.6 F = 1800
17.0 EL 172.6 F = 3600
21.0 EL 168.6 F = 1200
24.0 EL 165.6 F = 720

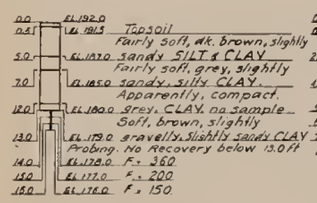
T-1739a


0.0 EL 187.2
0.8 EL 186.4 Topsoil
Soft, brown, slightly sandy, silty CLAY
6.0 EL 181.2
9.0 EL 178.2 Soft, grey, slightly sandy, CLAY
11.0 EL 176.2 Very soft, blueish grey CLAY
Probing No Recovery below 11.0 ft
12.0 EL 175.2 F = 3600
14.0 EL 173.2 F = 7200
17.0 EL 170.2 F = 3600
21.0 EL 166.2 F = 1800

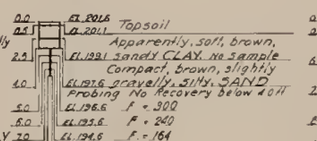
T-1740a


0.0 EL 188.6
0.6 EL 188.0 Topsoil
Fairly soft, brown, Slightly
7.0 EL 181.6 sandy, silty CLAY
Soft, grey, slightly sandy,
10.0 EL 178.6 Silty CLAY
Probing No Recovery below 10.0 ft
11.0 EL 177.6 F = 3600
13.0 EL 175.6 F = 7200
17.0 EL 171.6 F = 3600
21.0 EL 167.6 F = 1800

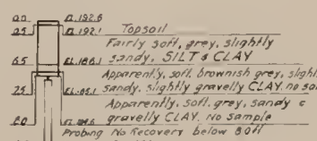
T-1741a


0.0 EL 192.0
0.8 EL 191.3 Topsoil
Fairly soft, dk. brown, slightly
5.0 EL 187.0 sandy SILT & CLAY
Fairly soft, grey, slightly
7.0 EL 185.0 sandy, silty CLAY
Apparently, compact.
12.0 EL 180.0 grey, CLAY. no sample
Soft, brown, slightly
13.0 EL 179.0 gravelly, slightly sandy CLAY
Probing. No Recovery below 13.0 ft
14.0 EL 178.0 F = 360
15.0 EL 177.0 F = 200
15.0 EL 176.0 F = 150

T-1742a


0.0 EL 201.6
0.5 EL 201.1 Topsoil
Apparently, soft, brown,
2.5 EL 199.1 sandy CLAY. No Sample
Compact, brown, slightly
6.0 EL 195.6 gravelly, silty, SAND
Probing No Recovery below 6.0 ft
5.0 EL 196.6 F = 300
5.0 EL 195.6 F = 240
7.0 EL 194.6 F = 164
8.0 EL 193.6 F = 138

T-1743a


0.0 EL 192.6
0.5 EL 192.1 Topsoil
Fairly soft, grey, slightly
6.5 EL 186.1 sandy, SILT & CLAY
Apparently, soft, brownish grey, slightly
7.5 EL 185.1 Sandy, slightly gravelly CLAY. no sample
Apparently, soft, grey, sandy &
8.0 EL 184.6 gravelly CLAY. No Sample
Probing No Recovery below 8.0 ft
8.5 EL 184.1 F = 130

NOTE:

Analyses of overburden are based on dry samples.
Elevations are based on U.S.G.S. datum M.S.L. 1912 adjustment.

Holes numbered greater than D15D0 drilled with 2½" casing. T-D00-a denotes 3" diameter hand auger holes to refusal or no recovery and extended by hand probing. Probing made with ¾" rod driven with 14# sledge. F-00 denotes rate of probing penetration in feet per hour.
See sheet File No. M-C-A-7/6 for descriptive terms.

TRANSVERSE MERCATOR COORDINATES

HOLE NO	NORTH	EAST	HOLE NO	NORTH	EAST
T-1721-a	1,815,617.48	371,665.84	T-1733-a	1,816,608.40	374,844.44
T-1722-a	1,815,735.25	372,355.86	T-1734-a	1,816,970.13	376,963.79
T-1723-a	1,815,953.10	372,318.68	T-1735-a	1,816,752.28	377,000.97
T-1724-a	1,816,170.95	372,281.50	T-1736-a	1,816,534.43	377,038.15
T-1725-a	1,816,238.25	372,875.80	T-1737-a	1,816,626.97	377,580.30
T-1726-a	1,816,020.40	372,712.98	T-1738-a	1,817,062.67	377,505.94
T-1727-a	1,815,802.55	372,750.16	T-1739-a	1,817, 80.44	378,195.97
T-1728-a	1,815,903.50	373,341.60	T-1740-a	1,816,962.59	378,233.15
T-1729-a	1,816,021.27	374,031.62	T-1741-a	1,816,744.74	378,270.33
T-1730-a	1,816,239.12	373,994.44	T-1742-a	1,816,938.23	379,403.93
T-1731-a	1,816,456.97	373,957.26	T-1743-a	1,817,030.76	379,946.09
T-1732-a	1,816,356.90	374,684.47			

ST LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION EXPLORATION NO. 15

IN SHEETS · SHEET NO · SCALE: 1IN = 10FT.

10 0 10 20

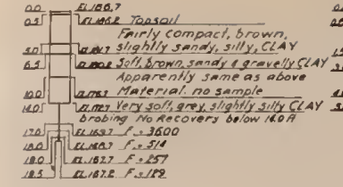
U. S. ENGINEER OFFICE, MASSENA NEW YORK FEBRUARY 1942

SUBMITTED	RECOMMENDED	APPROVED
R.M. Hanna, ENGINEER	LT. COL. CORPS OF ENGINEERS	DIVISION ENGINEER

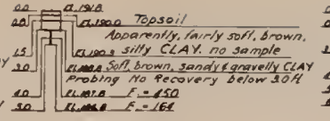
DRAWN BY W.J.H. CHECKED BY · FILE NO. MC-A-2/28 TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 194

PLATE III-29

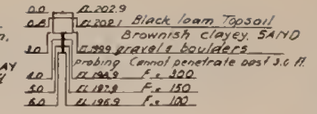
T-1744a


0.0 EL 180.7
0.5 EL 180.2 Topsoil
Fairly compact, brown, slightly sandy, silty CLAY
5.0 EL 175.7
6.5 EL 174.2 Soft, brown, sandy & gravelly CLAY
Apparently same as above
10.0 EL 170.7 Material, no sample
14.0 EL 166.7 Very soft, grey, slightly silty CLAY
Probing No Recovery below 14.0 ft
17.0 EL 163.7 F = 3600
18.0 EL 162.7 F = 514
18.5 EL 162.2 F = 257
18.5 EL 161.2 F = 129

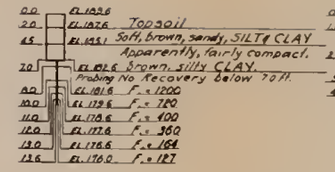
T-1745a


0.0 EL 174.8
0.8 EL 174.0 Topsoil
Apparently, fairly soft, brown, silty CLAY, no sample
1.5 EL 173.3
3.0 EL 171.8 Soft, brown, sandy & gravelly CLAY
Probing No Recovery below 3.0 ft
4.0 EL 170.8 F = 450
5.0 EL 169.8 F = 164

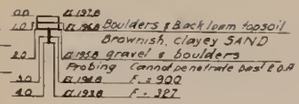
T-1746a


0.0 EL 202.9
0.8 EL 202.1 Black loam Topsoil
Brownish clayey SAND
2.0 EL 199.9 gravel & boulders
probing Cannot penetrate past 3.0 ft
4.0 EL 198.9 F = 300
5.0 EL 197.9 F = 150
6.0 EL 196.9 F = 100

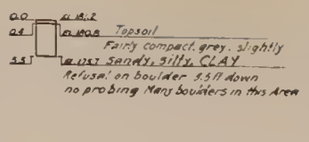
T-1747a


0.0 EL 182.6
2.0 EL 180.6 Topsoil
2.5 EL 180.1 Soft, brown, sandy, SILT & CLAY
Apparently, fairly compact.
7.0 EL 175.6 Brown, silty CLAY
Probing No Recovery below 7.0 ft.
10.0 EL 172.6 F = 1200
11.0 EL 171.6 F = 780
12.0 EL 170.6 F = 400
13.0 EL 169.6 F = 360
13.6 EL 169.0 F = 164
EL 168.0 F = 127

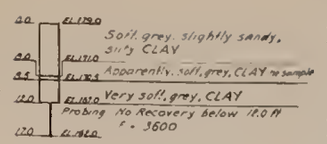
T-1748a


0.0 EL 197.8
1.0 EL 196.8 Boulders & Black loam topsoil
Brownish, clayey SAND
2.0 EL 195.8 gravel & boulders
Probing Cannot penetrate past 2.0 ft
3.0 EL 194.8 F = 900
4.0 EL 193.8 F = 327

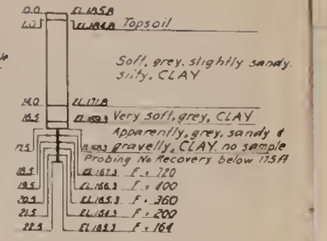
T-1749a


0.0 EL 181.2
0.8 EL 180.8 Topsoil
Fairly compact, grey, slightly
2.5 EL 178.7 Sandy, Silty, CLAY
Refusal on boulder 2.5 ft down
no probing Many boulders in this Area

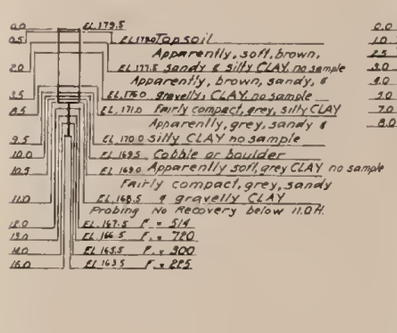
T-1750a


0.0 EL 173.0
Soft, grey, slightly sandy, silty CLAY
2.5 EL 170.5
Apparently, soft, grey, CLAY no sample
4.0 EL 169.0 Very soft, grey, CLAY
Probing No Recovery below 12.0 ft
12.0 EL 162.0 F = 3600

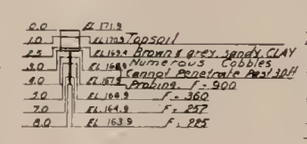
T-1751a


0.0 EL 185.8
1.0 EL 184.8 Topsoil
Soft, grey, slightly sandy, silty, CLAY
4.0 EL 181.8
4.5 EL 181.3 Very soft, grey, CLAY
Apparently, grey, sandy & gravelly, CLAY no sample
Probing No Recovery below 17.5 ft
18.5 EL 167.3 F = 720
19.5 EL 166.3 F = 400
20.9 EL 164.9 F = 360
21.5 EL 164.3 F = 200
22.5 EL 163.3 F = 164

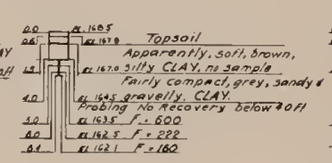
T-1752a


0.0 EL 179.5
0.5 EL 179.0 Topsoil
Apparently, soft, brown,
2.0 EL 177.5 sandy & silty CLAY no sample
Apparently, brown, sandy, &
3.5 EL 176.0 Gravelly CLAY no sample
4.5 EL 171.0 Fairly compact, grey, silty CLAY
Apparently, grey, sandy &
9.5 EL 170.0 silty CLAY no sample
10.0 EL 169.5 Cobble or boulder
10.5 EL 169.0 Apparently soft, grey CLAY no sample
Fairly compact, grey, sandy
11.0 EL 168.5 & gravelly CLAY
Probing No Recovery below 11.0 ft.
12.0 EL 167.5 F = 514
13.0 EL 166.5 F = 720
14.0 EL 165.5 F = 300
16.0 EL 163.5 F = 225

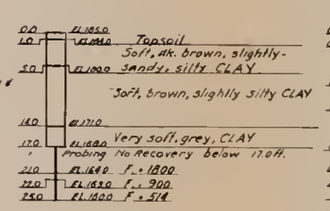
T-1753a


0.0 EL 171.9
1.0 EL 170.9 Topsoil
2.5 EL 169.4 Brown & grey, sandy CLAY
5.0 EL 166.9 Numerous Cobbles
Cannot Penetrate Past 30 ft
7.0 EL 164.9 Probing F = 900
8.0 EL 163.9 F = 360
F = 257
F = 225

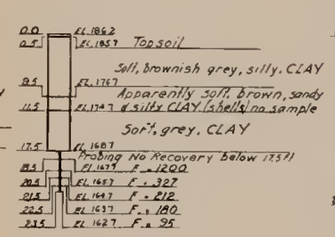
T-1754a


0.0 EL 168.5
0.8 EL 167.8 Topsoil
Apparently, soft, brown,
1.5 EL 167.0 silty CLAY, no sample
Fairly compact, grey, sandy &
4.0 EL 164.5 gravelly, CLAY
Probing No Recovery below 7.0 ft
5.0 EL 163.5 F = 600
6.0 EL 162.5 F = 228
6.4 EL 162.1 F = 160

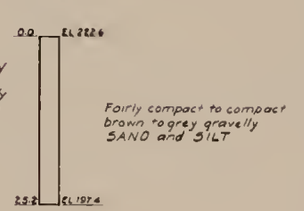
T-1755a


0.0 EL 185.0
1.0 EL 184.0 Topsoil
Soft, dk. brown, slightly-
5.0 EL 180.0 sandy, silty CLAY.
Soft, brown, slightly silty CLAY
14.0 EL 171.0
17.0 EL 168.0 Very soft, grey, CLAY
Probing No Recovery below 17.0 ft.
21.0 EL 164.0 F = 1800
22.0 EL 163.0 F = 900
23.0 EL 162.0 F = 514

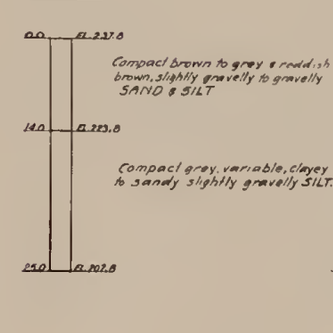
T-1756a


0.0 EL 186.2
0.5 EL 185.7 Topsoil
Soft, brownish grey, silty CLAY
8.5 EL 176.7
Apparently soft, brown, sandy
11.5 EL 173.7 & silty CLAY (shells) no sample
Soft, grey, CLAY
17.5 EL 167.7
Probing No Recovery below 17.5 ft
18.5 EL 166.7 F = 1200
19.5 EL 165.7 F = 327
21.5 EL 164.7 F = 212
22.5 EL 163.7 F = 180
23.5 EL 162.7 F = 95

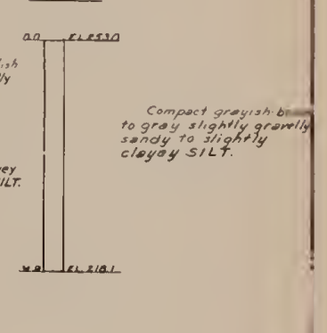
D-1757



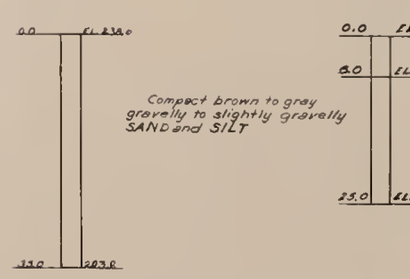
D-1758


0.0 EL 237.8
Compact brown to grey & reddish brown, slightly gravelly to gravelly SAND & SILT
14.0 EL 223.8
Compact grey, variable, clayey to sandy slightly gravelly SILT.
29.0 EL 208.8

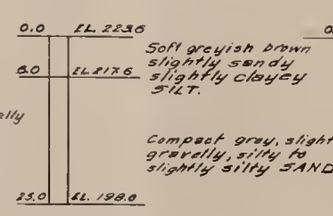
D1759



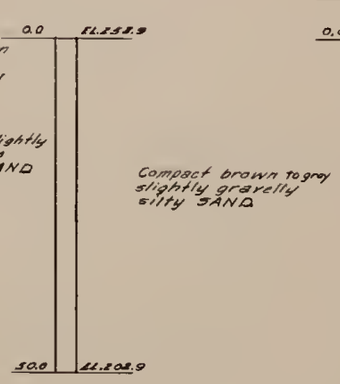
D1760



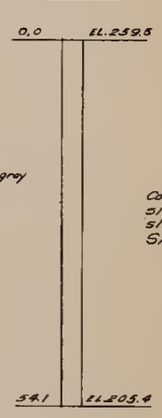
D1761


0.0 EL 223.6
Soft greyish brown slightly sandy slightly clayey SILT.
8.0 EL 215.6
Compact gray, slightly gravelly, silty to slightly silty SAND
25.0 EL. 198.6

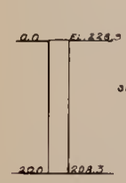
D1762



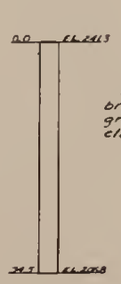
D1763



D1764



D 1765



NOTE:
Analyses of overburden are based on dry samples.
Elevations are based on U.S.G.S. datum M.S.L. 1912 adj.

Holes numbered greater than D1500 drilled with 2½" casing.
T-000-a denotes 5" diameter hand auger holes to refusal or no recover and extended by hand probing. Probing made with ¾" rod driven with 14" sledge.
F-00 denotes rate of probing penetration in feet per hour
See sheet File No. MC-A-3/14 for descriptive terms.

TRANSVERSE MERCATOR COORDINATES

HOLE NO.	NORTH	EAST	HOLE NO.	NORTH	EAST
T1744a	1,817,248.61	379,908.91	T1755a	1,817,829.07	383,309.73
T1745a	1,817,357.97	380,549.65	T1756a	1,818,046.98	383,272.55
T1746a	1,817,140.12	380,586.83	D1757	1,813,776	360,205
T1747a	1,817,342.02	381,769.72	D1758	1,813,425	357,776
T1748a	1,817,426.13	382,262.59	D1759	1,812,646	355,224
T1749a	1,817,644.00	382,283.41	D1760	1,812,380	354,047
T1750a	1,817,861.85	382,188.23	D1761	1,811,791	351,998
T1751a	1,817,971.21	382,828.97	D1762	1,811,621	350,701
T1752a	1,817,753.36	382,866.15	D1763	1,811,445	349,926
T1753a	1,817,535.51	382,903.33	D1764	1,811,091	348,361
T1754a	1,817,611.22	383,316.91	D1765	1,810,829	347,206

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
RECORD OF FOUNDATION EXPLORATION NO. 16

IN SHEETS | SHEET NO | SCALE: 1 IN = 10 FT.
10 0 10 20
U. S. ENGINEER OFFICE, MASSENA, NEW YORK FEBRUARY 1942
SUBMITTED P. M. Hamer ENGINEER
RECOMMENDED O. Ballard LT. COL. CORPS OF ENGINEERS
APPROVED CHIEF OF ENGINEERS
DIVISION ENGINEER
DRAWN BY W.J.H. CHECKED BY M.F.
FILE NO MC-A-2/29
TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 194

D1766

0.0 EL. 243.6
Fairly compact to compact brown slightly gravelly to gravelly SAND and SILT.
13.4 EL. 230.2
Compact grey slightly gravelly SAND and SILT.
40.0 EL. 203.6

D-1767

0.0 EL. 219.0
Fairly compact brown slightly clayey SILT & SAND
9.0 EL. 210.0
Fairly compact to soft, brownish grey to grey silty to slightly silty, slightly sandy CLAY.
38.5 BOS.

D-1768

0.0 EL. 216
Compact brown slightly gravelly SAND & SILT
14.0 EL. 214
Compact grey sandy slightly gravelly SILT
23.7 EL. 209.3

D-1769

0.0 EL. 229.7
Compact brown slightly gravelly SAND & SILT.
20.0 EL. 209.7
Compact grey slightly sandy to sandy slightly gravelly SILT.
24.5 EL. 205.2

D-1770

2.0 EL. 216.7
Compact, yellowish brown to grey, sandy, slightly gravelly to slightly clayey SILT.
25.0 EL. 203.7

D-1771

0.0 EL. 223.4
Compact, greyish brown, slightly clayey SILT
6.0 EL. 223.4
Fairly soft, brownish grey to grey, silty, slightly sandy CLAY
23.0 EL. 206.4
Compact, grey, sandy, slightly clayey SILT
26.0 EL. 203.4

D-1772

0.0 EL. 233.2
Soft grey-brown slightly clayey SAND & SILT
5.5 EL. 227.5
Soft grey-brown slightly sandy CLAY & SILT
13.0 EL. 220.2
Soft grey silty to slightly sandy slightly gravelly CLAY
27.5 EL. 205.7
Compact grey slightly silty, slightly gravelly SAND
30.0 EL. 203.2

D1773

0.0 EL. [illegible]
Soft grey-brown slightly sandy CLAY and SILT.
3.3 EL. 229.9
Fairly compact to compact grey-brown to grey gravelly SAND and SILT.
30.0 EL. 203.2

D1774

0.0 EL. 187.2
Soft variable brownish grey to grey, slightly sandy SILT & CLAY.
14.0 EL. 173.2
Soft grey, slightly silty CLAY.
29.0 EL. 158.2
Compact grey slightly clayey, slightly gravelly silty SAND
36.5 EL. 150.7
Compact grey, slightly gravelly silty SAND.
44.0 EL. 143.2

D1775

0.0 EL. 186.7
Soft brownish grey slightly sandy SILT & CLAY.
17.0 EL. 169.7
Compact grey slightly clayey slightly gravelly silty SAND.
EL. 158.7

D1776

0.0 EL. 186.9
Soft brownish grey slightly sandy SILT & CLAY.
13.5 EL. 173.4
Soft grey silty CLAY.
28.0 EL. 158.9
Compact grey slightly gravelly silty SAND.
34.0 EL. 152.9

D1777

0.0 EL. 187.0
Soft brownish grey slightly sandy SILT & CLAY.
13.5 EL. 173.5
Soft grey silty CLAY.
30.3 EL. 156.7
Compact grey slightly gravelly silty SAND.
45.3 EL. 141.7

D1778

0.0 EL. 186.0
Soft brown, slightly sandy slightly clayey SILT.
7.0 EL. 179.0
Soft grey silty CLAY.
13.0 EL. 173.0
Soft grey silty CLAY.
EL. 150.3
Compact grey slightly gravelly silty SAND.
31.3 EL. 135.3

D1779

0.0 EL. 186.1
Soft brownish grey, slightly sandy silty CLAY.
12.8 EL. 173.3
Soft grey silty CLAY.
38.0 EL. 148.1
Compact grey, slightly gravelly silty SAND.
53.0 EL. 133.1

D1780

0.0 EL. 185.4
Soft brownish grey slightly sandy silty CLAY.
14.0 EL. 171.4
Soft grey silty CLAY.
38.0 EL. 147.4
Compact grey slightly gravelly silty SAND.
51.5 EL. 133.9

D1781

0.0 EL. 184.9
Fairly compact brownish grey, slightly sandy SILT & CLAY.
13.0 EL. 171.0
Soft grey silty CLAY.
Compact grey slightly gravelly silty SAND.
Compact grey slightly silty SAND.
37.2 EL. 147.6
43.0 EL. 141.9
44.4 EL. 140.5
Compact grey slightly gravelly silty SAND.
48.5 EL. 136.4
Compact brown SAND.
53.0 EL. 131.9

D1782

0.0 EL. 184.3
Fairly compact brownish grey slightly sandy SILT & CLAY.
14.3 EL. 171.1
Soft grey silty CLAY.
33.0 EL. 145.3
Compact grey slightly gravelly silty SAND.
44.0 EL. 134.3
Compact brown, uniform SAND.
47.0 EL. 131.3
Compact grey slightly gravelly silty SAND.

D1783

0.0 EL. 191.3
Fairly compact grey silty CLAY.
19.0 EL. 172.3
Soft grey silty CLAY.
46.7 EL. 144.6
Compact grey slightly gravelly silty SAND.
60.0 EL. 131.3

D1784

0.0 EL. 173.0
Fairly soft brownish grey, slightly sandy SILT & CLAY.
7.0 EL. 166.0
Compact grey slightly gravelly silty SAND.
33.0 EL. 139.0

D1785

0.0 EL. 191.3
Fairly compact brownish grey slightly sandy SILT & CLAY.
14.0 EL. 177.3
Fairly compact grey variable, slightly sandy slightly silty CLAY, to soft grey silty CLAY.
36.5 EL. 154.8
Compact grey slightly gravelly silty SAND.
46.5 EL. 144.3

D1786

0.0 EL. 166.2
Soft grey variable slightly silty slightly sandy CLAY to soft grey silty CLAY.
18.5 EL. 147.7
Compact grey slightly gravelly silty SAND.
35.0 EL. 131.2

D1787

0.0 EL. 183.0
Fairly compact brownish grey, slightly sandy SILT & CLAY.
15.0 EL. 168.0
Soft grey silty CLAY.
39.0 EL. 144.0
Compact grey slightly gravelly silty SAND.
59.0 EL. 124.0

D1788

0.0 EL. 183.0
Fairly soft brownish grey slightly sandy SILT & CLAY.
15.9 EL. 167.1
Soft grey silty CLAY.
45.2 EL. 137.8
Fairly compact slightly gravelly silty SAND.
51.0 EL. 132.0

D1789

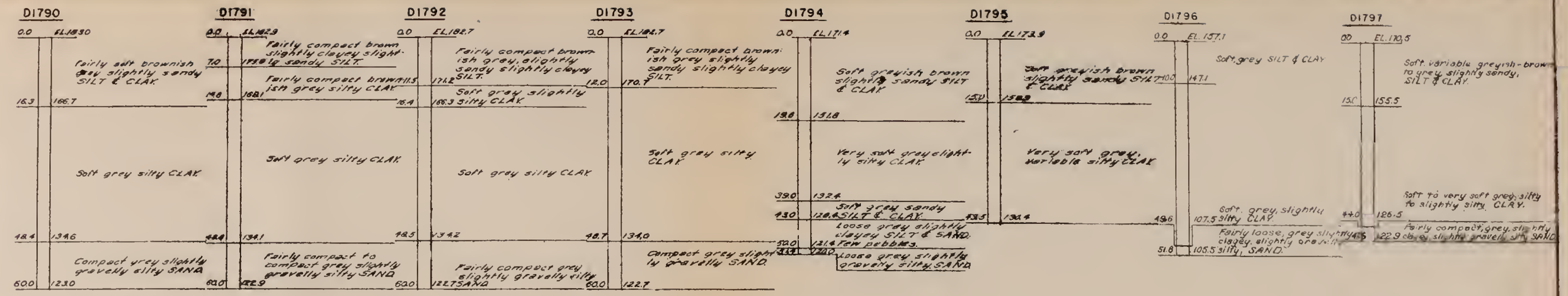
0.0 EL. 183.0
Fairly soft brownish grey slightly sandy SILT & CLAY.
15.5 EL. 167.5
Soft grey silty CLAY.
Soft grey slightly gravelly slightly sandy silty CLAY.
45.1 EL. 137.9
47.0 EL. 136.0
Compact grey slightly gravelly silty SAND.
60.0 EL. 123.0

NOTE:
Analyses of over burden are based on dry samples.
Elevations based on USGS datum M.S.L. 1912 adjustment.
Holes numbered greater than D1500 drilled with 2½" casing.
See sheet File No. MC-A-1 for descriptive terms.
See sheet File No. MC-A-3 for coordinates of holes.

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
RECORD OF FOUNDATION
EXPLORATION NUMBER

SHEET NO. SCALE 1" = 10'
U.S. ENGINEER OFFICE MASSENA, NEW YORK FEBRUARY 194
FILE NO. MC-A-2/30

PLATE III-31



NOTE:

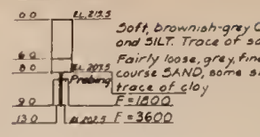
Analyses of overburden are based on dry samples.
Analyses of bed rock are based on 2" rock cores obtained by drilling.
Elevations are based on U.S.C. & G.S. datum.
Holes numbered greater than D1791 drilled with 2½" casing.
See sheet File No. MC-A 9.1 for descriptive terms.
See sheet File No. MC-A 9.3 for coordinates of holes.

ST LAWRENCE RIVER PROJECT
LONG SAULT CANAL
RECORD OF FOUNDATION EXPLORATION
NO. 18

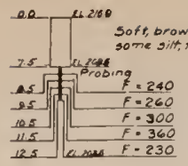
19 SHEETS	SHEET NO.	SCALE 1"=10' VERTICAL
U.S. ENGINEER OFFICE, MASSENA, NEW YORK		FEBRUARY 1942
SUBMITTED: R. M. Hamer, ENGINEER	RECOMMENDED: [illegible], LT. COL., CORPS OF ENGINEERS	APPROVED: [illegible], COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
DIV. NO. [illegible]	FILE NO. MC-A-2/31	TRANSMITTED WITH LETTER OR ENDORSEMENT DATED _____ 19__

PLATE III-32

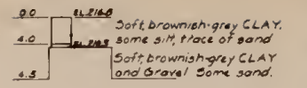
T-1800a


0.0 EL 213.3
Soft, brownish-grey CLAY and SILT. Trace of sand
6.0
8.0 EL 207.3
Fairly loose, grey, fine to course SAND, some silt, trace of clay
Probing
9.0
13.0 EL 200.3 F = 3600

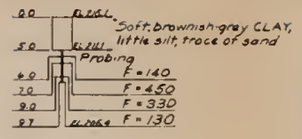
T-1801a


0.0 EL 216.0
Soft, brownish-grey CLAY, some silt, trace of sand
7.5 EL 208.5
Probing
8.5 F = 240
9.5 F = 260
10.5 F = 300
11.5 F = 360
12.5 EL 203.5 F = 230

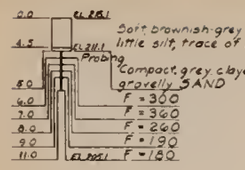
T-1802a



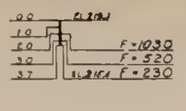
T-1803a



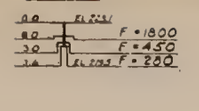
T-1804a


0.0 EL 216.1
Soft brownish-grey CLAY, little silt, trace of sand
4.5 EL 211.1
Probing
Compact, grey clayey, silty, gravelly SAND
6.0 F = 300
7.0 F = 360
8.0 F = 260
9.0 F = 190
11.0 EL 202.1 F = 180

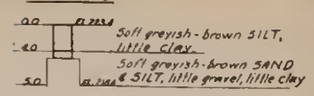
P-1805



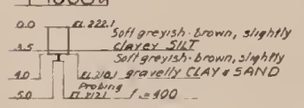
P-1806



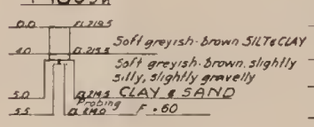
T-1807a



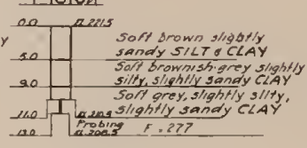
T-1808a



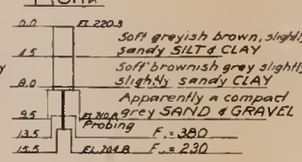
T-1809a


0.0 EL 218.5
Soft greyish-brown SILT & CLAY
4.0 EL 214.5
Soft greyish-brown, slightly silty, slightly gravelly
5.0 EL 213.5 CLAY & SAND
Probing
5.5 EL 213.0 F = 60

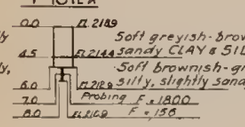
T-1810a


0.0 EL 221.5
Soft brown slightly sandy SILT & CLAY
5.0
Soft brownish-grey slightly silty, slightly sandy CLAY
9.0
Soft grey, slightly silty, slightly sandy CLAY
11.0 EL 210.5
Probing
13.0 EL 206.5 F = 277

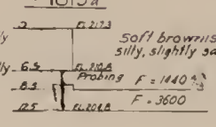
T-1811a


0.0 EL 220.3
Soft greyish brown, slightly sandy SILT & CLAY
4.5
Soft brownish grey slightly, slightly sandy CLAY
8.0
Apparently a compact grey SAND & GRAVEL
9.5 EL 210.8
Probing F = 380
13.5
15.5 EL 204.8 F = 230

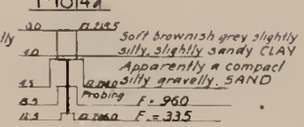
T-1812a


0.0 EL 218.9
Soft greyish-brown, slightly sandy CLAY & SILT.
4.5 EL 214.4
Soft brownish-grey, slightly silty, slightly sandy CLAY
6.0 EL 212.9
Probing F = 1800
7.0
8.0 EL 210.9 F = 156

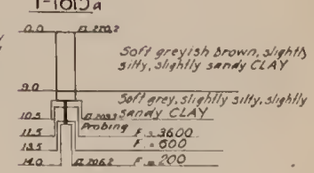
T 1813a


0.0 EL 217.3
Soft brownish grey, slightly silty, slightly sandy CLAY
6.5 EL 210.8
Probing F = 1440
8.5
Probing F = 960
12.5 EL 204.8 F = 3600

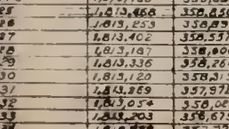
T-1814a


0.0 EL 218.5
Soft brownish grey slightly silty, slightly sandy CLAY
4.0
Apparently a compact Silty gravelly SAND
4.5 EL 214.0
Probing F = 960
6.3
11.5 EL 206.0 F = 335

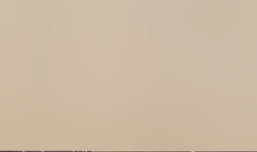
T-1815a


0.0 EL 220.2
Soft greyish brown, slightly silty, slightly sandy CLAY
9.0
Soft grey, slightly silty, slightly sandy CLAY
10.5 EL 209.2
Probing F = 3600
11.5 F = 600
13.5
14.0 EL 206.2 F = 200

T-1816a

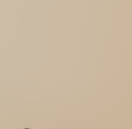


T-1817a


0.0 EL 219.4
Soft greyish brown, slightly silty, slightly sandy CLAY
8.0
Soft, grey slightly silty CLAY
10.5
11.0 EL 208.4 Loose grey clayey SAND & SILT
Probing F = 300
13.0
13.2 EL 206.2 F = 180

T-1818a

T-1819a



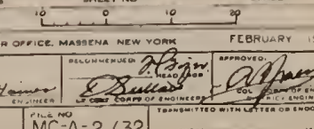
T-1820a

T-1821a

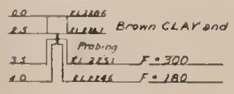
0.0 EL 218.6
Soft greyish brown slightly sandy CLAY & SILT
4.0
Soft brown clayey, slightly gravelly SAND & SILT
5.0 EL 213.6
6.3 EL 212.1 Probing F = 110

T1822a

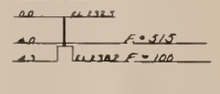
T1823a



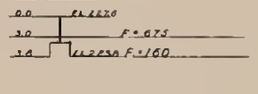
T1824a



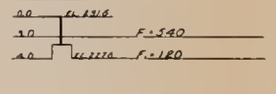
P1825



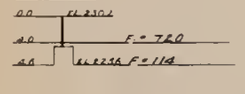
P1826



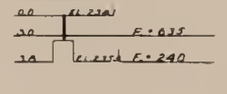
P1827



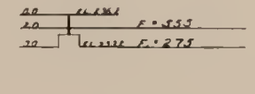
P1828



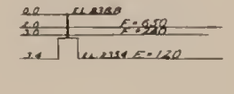
P1829



P1830

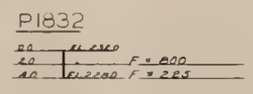


P1831

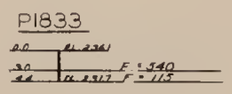


TRANSVERSE MERCATOR COORDINATES		
HOLE NO.	NORTH	EAST
T1800a	1,816,148	360,849
T1801a	1,816,186	360,751
T1802a	1,816,120	360,782
T1803a	1,815,986	360,605
T1804a	1,815,801	360,435
P1805	1,813,585	360,361
P1806	1,813,800	360,313
T1807a	1,813,971	360,069
T1808a	1,813,756	360,117
T1809a	1,813,560	360,166
T1810a	1,813,348	359,871
T1811a	1,813,736	360,020
T1812a	1,813,518	360,089
T1813a	1,813,451	359,776
T1814a	1,813,667	359,727
T1815a	1,813,883	359,879
T1816a	1,813,839	359,683
T1817a	1,813,623	359,532
T1818a	1,813,817	359,386
T1819a	1,813,601	359,433
T1820a	1,813,386	359,284
T1821a	1,813,352	359,337
T1822a	1,813,313	359,191
T1823a	1,813,535	359,148
T1824a	1,813,750	359,093
P1825	1,813,468	358,850
P1826	1,813,253	358,898
P1827	1,813,402	358,537
P1828	1,813,187	358,604
P1829	1,813,336	358,264
P1830	1,813,120	358,313
P1831	1,813,269	357,972
P1832	1,813,054	358,021
P1833	1,813,203	358,679
P1834	1,813,338	357,728

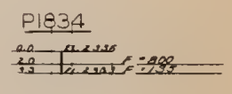
P1832



P1833



P1834



NOTES:

Analyses of overburden are based on dry samples.
Elevations are based on U.S.G.S. datum M.S.L. 1912 adj
T-000-a denotes 5" diameter hand auger holes to refusal or no recovery and extended by hand probing. Probing made with ¾" rod driven with 14 lb sledge.
P-000 denotes hand probing only.
F-denotes rate of probing penetration in feet per hour.
See sheet File No MC-1 for descriptive terms

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
RECORD OF FOUNDATION
EXPLORATION NUMBER 19

IN SHEETS | SHEET NO | SCALE 10 0 10 20

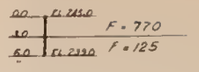
U S ENGINEER OFFICE, MASSENA NEW YORK — FEBRUARY 1942

SUBMITTED: R. M. Horner, ENGINEER
RECOMMENDED: E. Bullard, LT. COLONEL, CORPS OF ENGINEERS
APPROVED: [signature], COL. CORPS OF ENGINEERS, DIST. ENGINEER

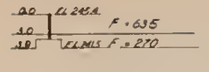
DRAWN BY | CHECKED BY MW | FILE NO MC-A-2/32 | TRANSMITTED WITH LETTER OR ENDORSEMENT DATED

PLATE III-33

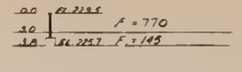
P-1835



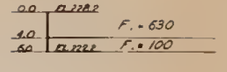
P-1836



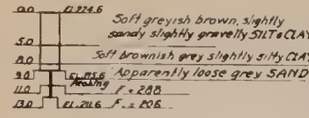
P-1837



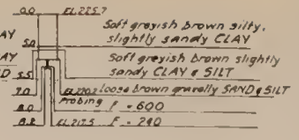
P-1838



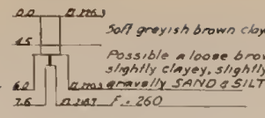
T-1839a



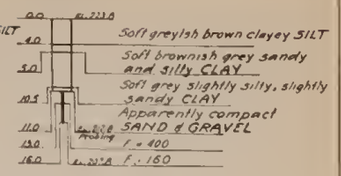
T-1840a


0.0 EL 225.7
Soft greyish brown silty, slightly sandy CLAY
5.0
Soft greyish brown slightly sandy CLAY & SILT
5.5
7.0 EL 220.2 Loose brown gravelly SAND & SILT
Probing F = 600
8.0
8.2 EL 217.5 F = 240

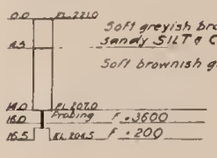
T-1841a


0.0 EL 226.3
Soft greyish brown clayey SILT
4.5
Possible a loose brown slightly clayey, slightly
6.2 EL 220.1 gravelly SAND & SILT
7.6 EL 218.7 F = 260

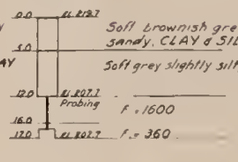
T-1842a


0.0 EL 223.0
Soft greyish brown clayey SILT
4.0
Soft brownish grey sandy and silty CLAY
5.0
Soft grey slightly silty, slightly sandy CLAY
10.5
Apparently compact SAND & GRAVEL
11.0
13.0 EL 212.8 Probing F = 400
16.0 EL 207.8 F = 160

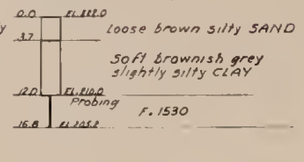
T-1843a



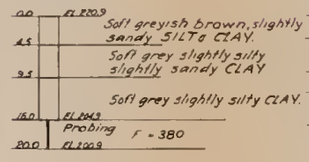
T-1644a



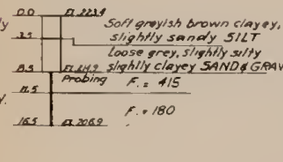
T-1845a



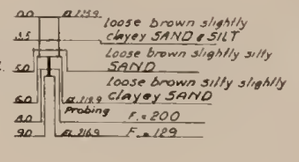
T-1846a



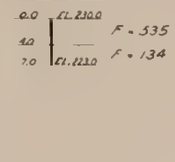
T-1847a



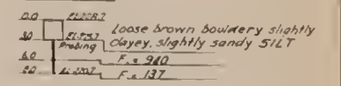
T-1848a



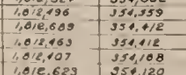
P-1849



T-1850a

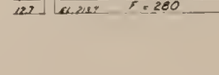


P-1851



T-1852a

P-1853



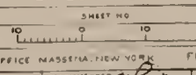
P-1854

P-1855

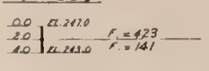
P-1856

P-1857

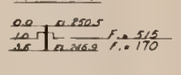
P-1858



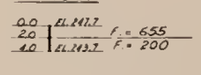
P-1859



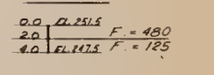
P-1860



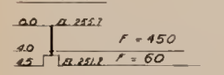
P-1861



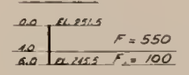
P-1862



P-1863



P-1864



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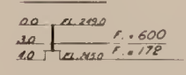
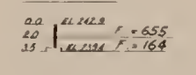
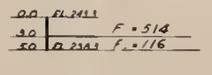


P-1866

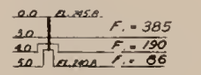


TRANSVERSE-MERCATOR-ORDINATES		
HOLE NO.	NORTH	EAST
P-835	1,813,137	356,367
P-836	1,812,921	357,436
P-837	1,813,071	356,094
P-838	1,813,288	357,045
T-839a	1,813,264	356,948
T-840a	1,813,048	356,997
T-841a	1,812,833	357,046
T-842a	1,813,026	356,899
T-843a	1,812,789	356,850
T-844a	1,813,004	356,802
T-845a	1,813,220	356,753
T-846a	1,812,787	356,753
T-847a	1,812,982	356,704
T-848a	1,813,198	356,655
P-849	1,813,153	356,460
P-850	1,812,938	356,309
P-851	1,812,722	356,558
T-852a	1,812,658	356,265
P-853	1,812,872	356,216
P-854	1,813,087	356,168
P-855	1,813,021	355,875
P-856	1,812,805	355,924
P-857	1,812,590	355,973
P-858	1,812,954	355,582
P-859	1,812,739	355,631
P-860	1,812,673	355,339
P-861	1,812,457	355,388
P-862	1,812,391	355,095
P-863	1,812,606	355,046
P-864	1,812,340	354,754
P-865	1,812,324	354,802
P-866	1,812,496	354,359
P-867	1,812,689	354,412
P-868	1,812,463	354,412
P-869	1,812,407	354,168
P-870	1,812,623	354,120
P-871	1,812,341	353,876
P-872	1,812,556	353,827
P-873	1,812,275	353,583
T-874a	1,812,445	353,545
T-875a	1,812,490	353,534
T-876a	1,812,325	353,372

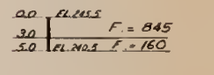
P-1867



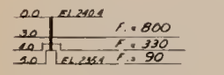
P-1868



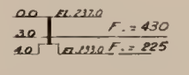
P-1869



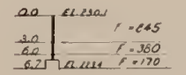
P-1870



P-1871



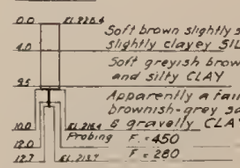
P-1872



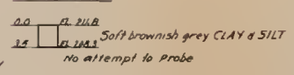
NOTE:

Analyses of overburden are based on dry samples.
Elevations based on U.S.G.S. datum, MSL (1912 adj.)
T-000-a denotes 5" diameter hand auger holes to refusal or no recovery and extended by hand probing Probing made with ¾" rod driven with 14 lb. Sledge.
P-000 denotes hand probing only.
F. denotes rate of probing penetration in feet per hour.
See sheet File No MC-A-2/14 for descriptive terms

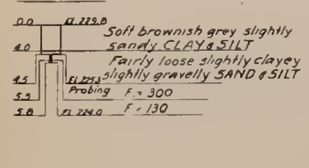
T-874a


0.0 EL 226.4
Soft brown slightly sandy, slightly clayey SILT
4.0
Soft greyish brown, sandy and silty CLAY
9.5
Apparently a fairly soft brownish-grey sandy
10.0 EL 216.4 & gravelly CLAY
Probing F. = 450
12.0
12.7 EL 213.7 F = 280

T-875a



T-876a


0.0 EL 229.8
Soft brownish grey slightly sandy CLAY & SILT
4.0
Fairly loose slightly clayey
4.5 EL 225.3 slightly gravelly SAND & SILT
Probing F. = 300
5.3
5.8 EL 224.0 F = 130

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
RECORD OF FOUNDATION
EXPLORATION NO. 20

IN SHEETS | SHEET NO | SCALE 1" = 10'

U S ENGINEER OFFICE MASSENA, NEW YORK FEBRUARY 1942

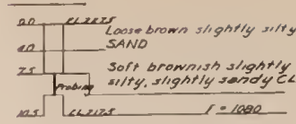
SUBMITTED R M Harmon
RECOMMENDED
APPROVED

DRAWN BY W.J.H.
CHECKED BY

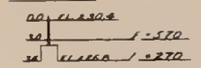
FILE NO MC-A-2/33

TRANSMITTED WITH LETTER OR ENDORSEMENT DATED

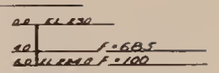
T1877a



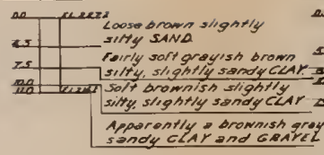
P1878



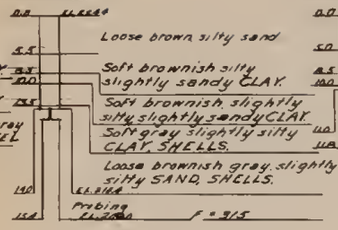
P1879



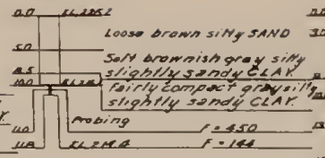
T1880a


0.0 EL 2223
Loose brown slightly silty SAND
6.5
Fairly soft grayish brown silty, slightly sandy CLAY
7.5
10.0
Soft brownish slightly silty, slightly sandy CLAY
11.0 EL 2112
Apparently a brownish gray sandy CLAY and GRAVEL

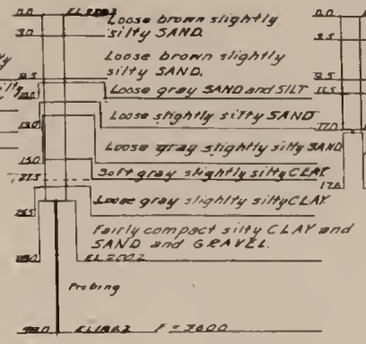
T1881a



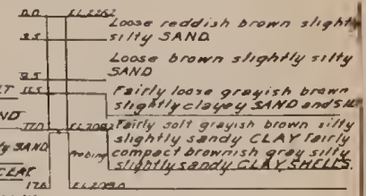
T1882a



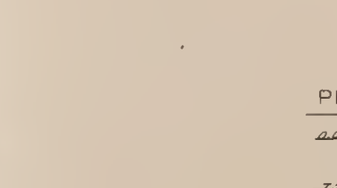
T1883a



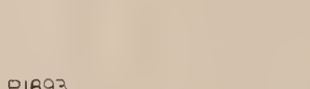
T1884a


0.0 EL 2252
Loose reddish brown slightly silty SAND.
2.5
Loose brown slightly silty SAND
9.5
Fairly loose grayish brown slightly clayey SAND and SILT
11.5
12.0 EL 2040
Probing
Fairly soft grayish brown silty slightly sandy CLAY, fairly compact brownish gray silty slightly sandy CLAY, SHELLS.
17.0 EL 2035

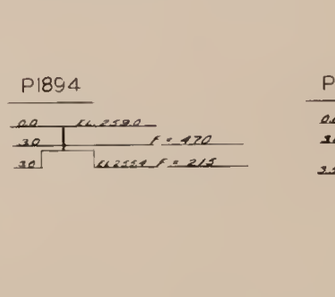
T1885a



T1886a



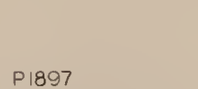
T1887a



T1888a

T1889a

P1890



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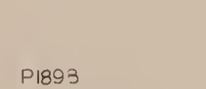

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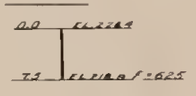

P1894

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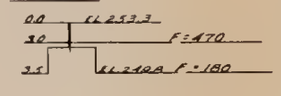

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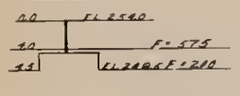

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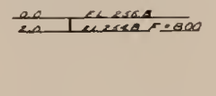

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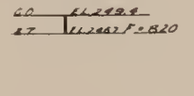

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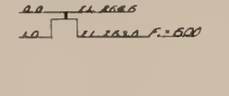


LOCATION OF HOLES BY TRANSVERSE MERCATOR COORDINATES

HOLE NUMBER	NORTH	EAST
T1877a	1,811,253	351,486
P1878	1,812,100	351,519
P1879	1,811,995	351,540
T1880a	1,812,090	351,317
T1881a	1,812,208	351,297
T1882a	1,811,961	351,791
T1883a	1,811,641	351,789
T1884a	1,811,636	351,847
T1885a	1,812,051	351,599
T1886a	1,812,012	351,423
T1887a	1,811,572	351,482
T1888a	1,811,788	351,438
T1889a	1,811,777	351,389
P1890	1,811,551	351,389
P1891	1,811,527	351,283
P1892	1,811,744	351,243
P1893	1,811,960	351,194
P1894	1,811,678	350,950
P1895	1,811,611	350,658
P1896	1,811,545	350,365
P1897	1,811,479	350,072
P1898	1,811,414	349,785
P1899	1,811,197	349,830

NOTES:

Analyses of overburden are based on dry samples.
Elevations based on U.S.G.S. datum. MSL 1912 adj.
T-000-a denotes 5" diameter hand auger holes to refusal or no recovery and extended by hand probing. Probing made with ¾" rod driven with 14 lb sledge.
P-000 denotes hand probing only
F- denotes rate of probing penetration in feet per hour.
See sheet File No MC-A-2 for descriptive terms

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
RECORD OF FOUNDATION
EXPLORATION NUMBER 21

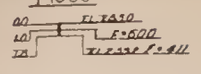
IN SHEETS | SHEET NO. | SCALE 0 5 10 50

U. S. ENGINEER OFFICE, MASSENA, NEW YORK — FEBRUARY 1942

SUBMITTED: R. M. Hamer, ENGINEER
RECOMMENDED: [illegible], ENGINEER; C. Bullard, LT. COL., CORPS OF ENGINEERS
APPROVED: [illegible], COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: R. E. S.
CHECKED BY: W. W.
FILE NO. MC-A-2/34
TRANSMITTED WITH LETTER OR ENDORSEMENT DATED _____ 194

P1900



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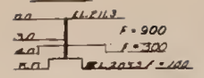

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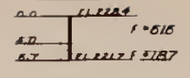

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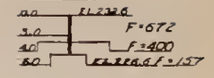

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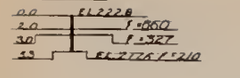

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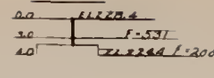

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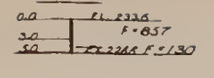

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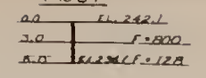

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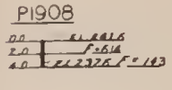

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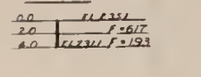

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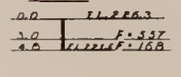

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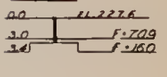

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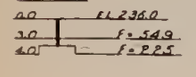

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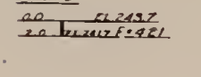

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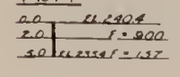

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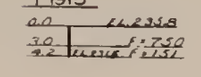

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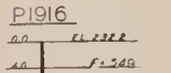

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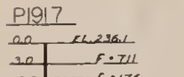

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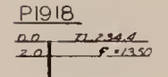

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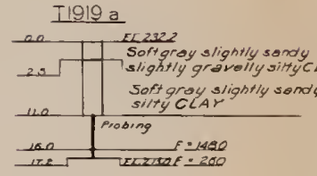

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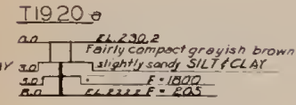

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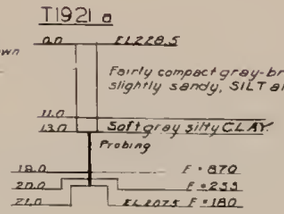
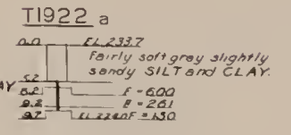

0.0 EL 2288.5
Fairly compact grey-brown, slightly sandy, SILT and CLAY
11.0
13.0 Soft gray silty CLAY
Probing
18.0 F = 870
20.0 F = 235
21.0 EL 2267.5 F = 180

T1922 a



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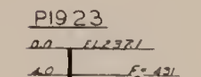

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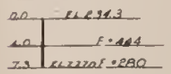

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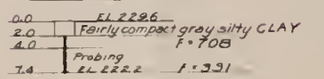

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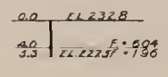

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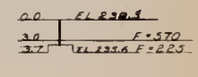

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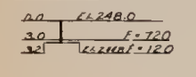

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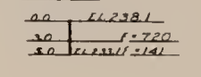

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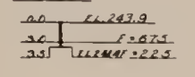

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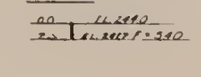

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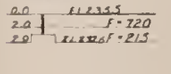

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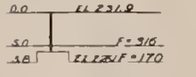

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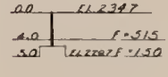

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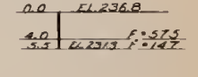
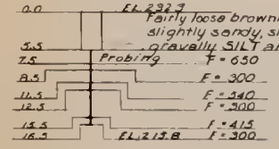
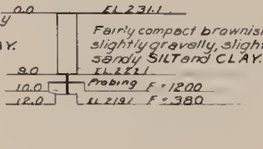


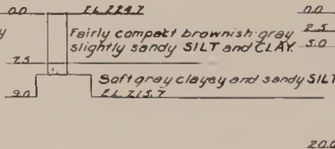
T1936 a


0.0 EL 2327
Fairly loose brownish gray slightly sandy, slightly gravelly SILT and CLAY.
3.5
7.5 Probing F = 650
8.5 F = 300
11.5 F = 340
12.5 F = 300
15.5 F = 415
16.3 EL 2215.8 F = 300

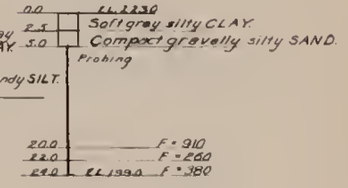
T1937 a


0.0 EL 2311
Fairly compact brownish-gray slightly gravelly, slightly sandy SILT and CLAY.
8.0 EL 2221
10.0 Probing F = 1200
12.0 EL 2191 F = 380

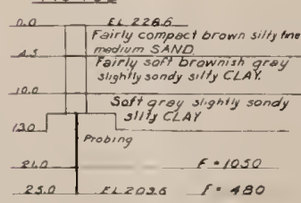
T1938 a



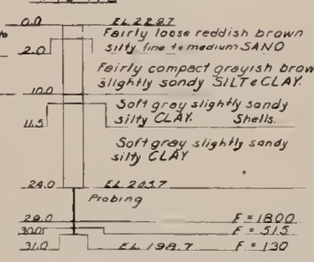
T1939 a



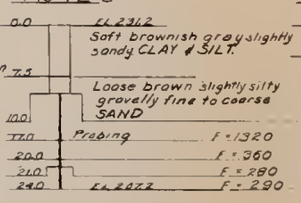
T1940 a



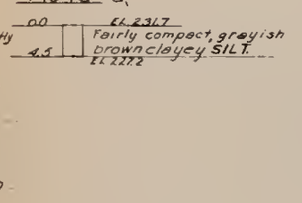
T1941 a


0.0 EL 2287
Fairly loose reddish brown silty fine to medium SAND
2.0
Fairly compact grayish brown slightly sandy SILT & CLAY.
10.0
Soft gray slightly sandy silty CLAY. Shells.
11.5
Soft gray slightly sandy silty CLAY
24.0 EL 2263.7
Probing
28.0 F = 1800
30.0 F = 515
31.0 EL 1989.7 F = 130

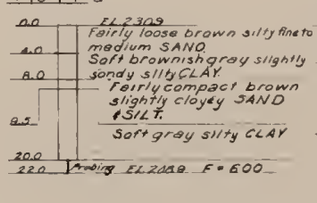
T1942 a


0.0 EL 2312
Soft brownish gray slightly sandy CLAY & SILT.
7.5
Loose brown slightly silty gravelly fine to coarse SAND
10.0
11.0 Probing F = 1320
20.0 F = 360
21.0 F = 280
24.0 EL 2072 F = 290

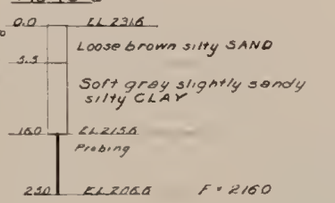
T1943 a



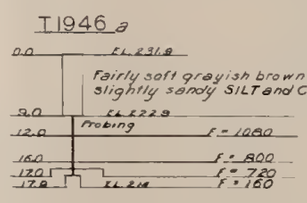
T1944 a


0.0 EL 2309
Fairly loose brown silty fine to medium SAND
4.0
Soft brownish gray slightly sandy silty CLAY.
8.0
Fairly compact brown slightly clayey SAND & SILT.
9.5
Soft gray silty CLAY
20.0
22.0 Probing EL 2048 F = 600

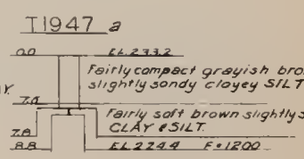
T1945 a



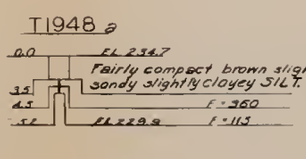
T1946 a



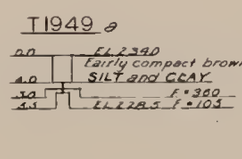
T1947 a


0.0 EL 2332
Fairly compact grayish brown slightly sandy clayey SILT
7.0
Fairly soft brown slightly sandy CLAY & SILT.
7.8
8.8 EL 2244 F = 1200

T1948 a



T1949 a



LOCATION OF HOLES BY TRANSVERSE MERCATOR COORDINATES

HOLE NUMBER	NORTH	EAST
P1900	1,811,159	349,663
P1901	1,811,185	348,776
P1902	1,811,400	348,727
P1903	1,811,341	348,463
P1904	1,811,125	348,512
P1905	1,810,976	348,258
P1906	1,811,059	348,219
P1907	1,811,274	348,170
P1908	1,811,208	347,878
P1909	1,810,992	347,527
P1910	1,810,838	347,362
P1911	1,810,710	347,683
P1912	1,810,926	347,634
P1913	1,811,142	347,585
P1914	1,810,860	347,342
P1915	1,810,644	347,390
P1916	1,810,578	347,098
P1917	1,810,793	347,049
P1918	1,810,847	346,832
T1919 a	1,810,749	346,854
T1920 a	1,810,539	346,803
T1921 a	1,810,512	346,805
T1922 a	1,810,727	346,756
P1923	1,810,802	346,637
P1924	1,810,705	346,639
T1925 a	1,810,683	346,708
P1926	1,810,415	346,513
P1927	1,810,660	346,464
P1928	1,810,876	346,415
P1929	1,810,729	346,220
P1930	1,810,594	346,171
P1931	1,810,528	345,879
P1932	1,810,313	345,928
P1933	1,810,248	345,635
P1934	1,810,462	345,586
P1935	1,810,677	345,537
T1936 a	1,810,655	345,440
T1937 a	1,810,440	345,489
T1938 a	1,810,224	345,538
T1939 a	1,810,424	345,420
T1940 a	1,810,180	345,368
T1941 a	1,810,395	345,294
T1942 a	1,810,611	345,245
T1943 a	1,810,545	344,952
T1944 a	1,810,329	345,001
T1945 a	1,810,114	345,050
T1946 a	1,810,097	344,7[illegible]
T1947 a	1,810,282	344,708
T1948 a	1,810,478	344,660
T1949 a	1,810,512	344,587

NOTE:

Analyses of overburden are based on dry samples.
Elevations are based on U.S.G.S. datum. M.S.L. 1912 adj.
T-000-a denotes 5" diameter hand auger holes to refusal or no recovery and extended by hand probing. Probing made with 1¼" rod driven with 14 lb sledge.
P-000 denotes hand probing only.
F- denotes rate of probing penetration in feet per hour.
See Sheet File No. MC-A-2/14 for descriptive terms

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION

EXPLORATION NO. 22

IN SHEETS — SHEET NO 1 — SCALE 1" = 10'

U.S. ENGINEER OFFICE MASSENA, NEW YORK FEBRUARY 1942

SUBMITTED R. M. Haines, ENGINEER

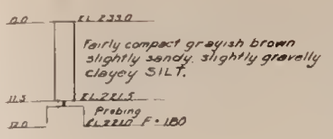
RECOMMENDED C. Sullivan, LT. COL. CORPS OF ENGINEERS, DIST. ENGINEER

APPROVED [illegible], COL. CORPS OF ENGINEERS, DIV. ENGINEER

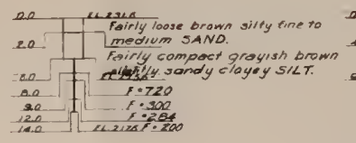
DRAWN BY R.E.B. CHECKED BY [illegible] FILE NO. MC-A-2/35

TRANSMITTED WITH LETTER OF THIS DATE DATED ----------

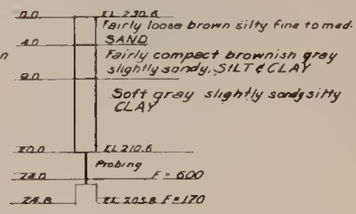
T1950 a


0.0 EL 233.0
Fairly compact grayish brown slightly sandy, slightly gravelly clayey SILT.
11.5 EL 221.5
Probing
12.0 EL 221.0 F = 180

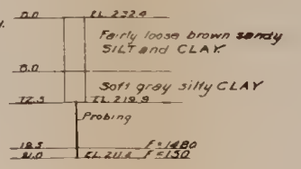
T1951 a


0.0 EL 231.6
Fairly loose brown silty fine to medium SAND.
2.0
Fairly compact grayish brown slightly sandy clayey SILT.
6.0 EL 225.6
6.0 F = 720
9.0 F = 300
12.0 F = 204
14.0 EL 217.6 F = 200

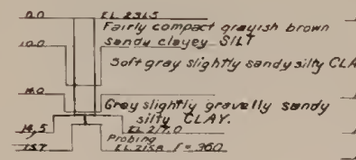
T1952 a


0.0 EL 230.6
Fairly loose brown silty fine to med. SAND
4.0
Fairly compact brownish gray slightly sandy, SILT & CLAY
9.0
Soft gray slightly sandy silty CLAY
20.0 EL 210.6
Probing
24.0 F = 600
24.8 EL 205.8 F = 170

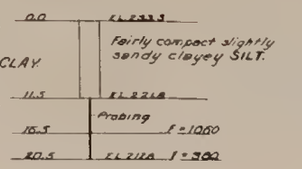
T1953 a



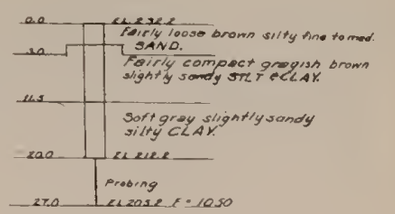
T1954 a



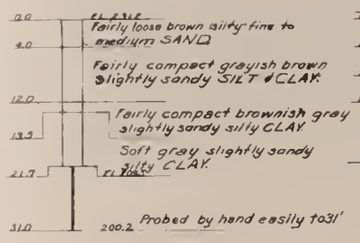
T1955 a



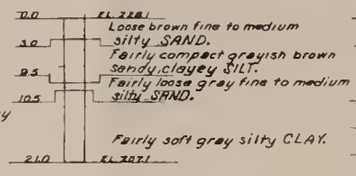
T1956 a


0.0 EL 234.2
Fairly loose brown silty fine to med. SAND.
3.0
Fairly compact grayish brown slightly sandy SILT & CLAY.
11.5
Soft gray slightly sandy silty CLAY.
20.0 EL 213.2
Probing
27.0 EL 203.2 F = 1050

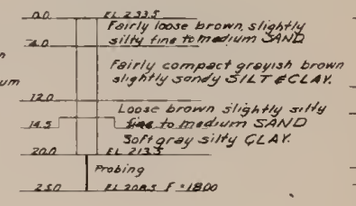
T1957 a


0.0 EL 234.2
Fairly loose brown silty fine to medium SAND
4.0
Fairly compact grayish brown slightly sandy SILT & CLAY.
12.0
Fairly compact brownish gray slightly sandy silty CLAY.
13.5
Soft gray slightly sandy silty CLAY.
21.7 EL 212.5
31.0 200.2 Probed by hand easily to 31'

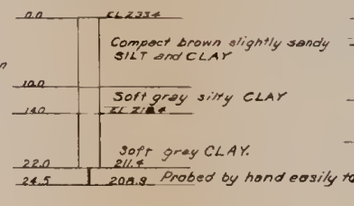
T1958 a


0.0 EL 228.1
Loose brown fine to medium silty SAND.
3.0
Fairly compact grayish brown sandy clayey SILT.
9.5
Fairly loose gray fine to medium silty SAND.
10.5
Fairly soft gray silty CLAY.
21.0 EL 207.1

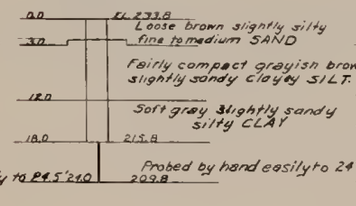
T1959 a


0.0 EL 233.5
Fairly loose brown slightly silty fine to medium SAND
4.0
Fairly compact grayish brown slightly sandy SILT & CLAY.
12.0
Loose brown slightly silty fine to medium SAND
14.3
Soft gray silty CLAY.
20.0 EL 213.5
Probing
25.0 EL 208.5 F = 1800

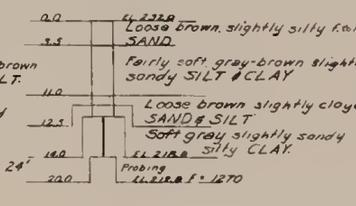
T1960 a



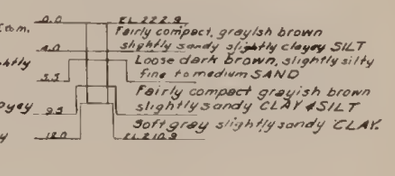
T1961 a


0.0 EL 233.8
Loose brown slightly silty fine to medium SAND
3.0
Fairly compact grayish brown slightly sandy clayey SILT.
12.0
Soft gray slightly sandy silty CLAY
18.0 215.8
Probed by hand easily to 24'
209.8

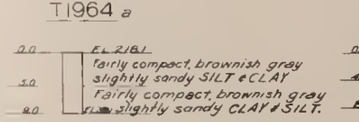
T1962 a


0.0 EL 232.9
Loose brown, slightly silty f.to m. SAND
3.5
Fairly soft gray-brown slightly sandy SILT & CLAY
11.0
Loose brown slightly clayey SAND & SILT
12.5
Soft gray slightly sandy silty CLAY.
16.0 EL 216.9
Probing
20.0 EL 212.9 F = 1270

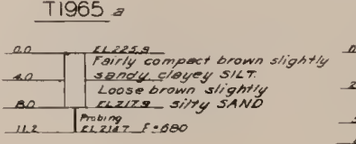
T1963 a


0.0 EL 222.9
Fairly compact, grayish brown slightly sandy slightly clayey SILT
4.0
Loose dark brown, slightly silty fine to medium SAND
5.5
Fairly compact grayish brown slightly sandy CLAY & SILT
9.5
Soft gray slightly sandy CLAY.
12.0 EL 210.9

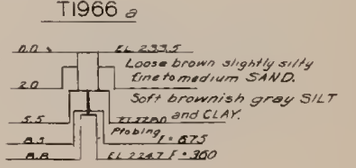
T1964 a


0.0 EL 216.1
Fairly compact, brownish gray slightly sandy SILT & CLAY
5.0
Fairly compact, brownish gray slightly sandy CLAY & SILT.
9.0

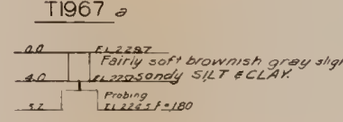
T1965 a



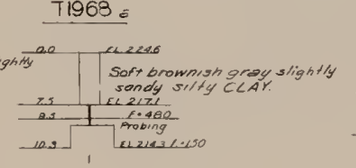
T1966 a


0.0 EL 233.5
Loose brown slightly silty fine to medium SAND.
2.0
Soft brownish gray SILT and CLAY.
5.5 EL 227.5
Probing
8.3 F = 875
8.8 EL 224.7 F = 300

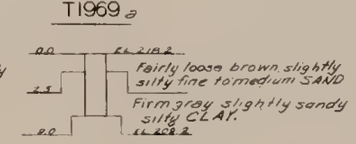
T1967 a



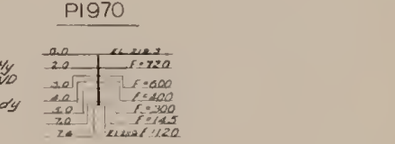
T1968 a



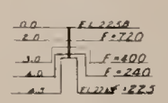
T1969 a



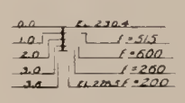
P1970



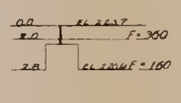
P1971



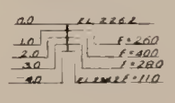
P1972



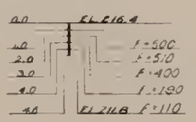
P1973



P1974



P1975



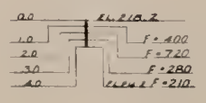
NOTES:

Analyses of overburden are based on dry samples.
Elevations based on USGS datum MSL 1912 adj.
T-000-a denotes 5" diameter hand auger holes to refusal or no recovery and extended by hand probing. Probing made with ¾" rod driven with 14# sledge
P-000-denotes hand probing only.
F- denotes rate of probing penetration in feet per hour.
See Sheet File No MC-A-2/6 for descriptive terms

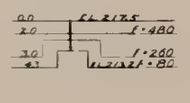
LOCATION OF HOLES BY TRANSVERSE MERCATOR COORDINATES

HOLE NO.	NORTH	EAST
T 1950 a	1,810,196	344,416
T 1951 a	1,809,951	344,465
T 1952 a	1,809,212	344,172
T 1953 a	1,810,130	344,123
T 1954 a	1,810,346	344,074
T 1955 a	1,810,279	343,782
T 1956 a	1,810,064	343,831
T 1957 a	1,809,848	343,880
T 1958 a	1,809,812	343,580
T 1959 a	1,809,997	343,538
T 1960 a	1,810,213	343,488
T 1961 a	1,810,147	343,187
T 1962 a	1,809,931	343,246
T 1963 a	1,809,790	343,278
T 1964 a	1,809,649	343,006
T 1965 a	1,809,865	342,953
T 1966 a	1,810,080	342,904
T 1967 a	1,810,014	342,612
T 1968 a	1,809,799	342,660
T 1969 a	1,809,583	342,709
P 1970	1,809,517	342,417
P 1971	1,809,732	342,368
P 1972	1,809,948	342,319
P 1973	1,808,876	342,002
P 1974	1,809,681	342,144
P 1975	1,809,188	339,969
P 1976	1,809,403	339,915
P 1977	1,809,336	339,691
P 1978	1,809,122	339,676
T 1979 a	1,808,517	339,086

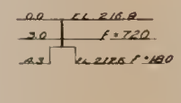
P1976



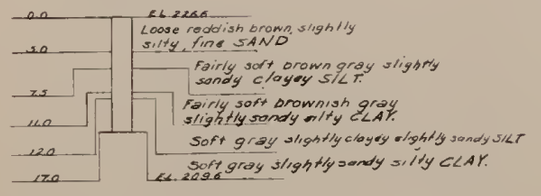
P1977



P1978



T1979 a


0.0 EL 226.6
Loose reddish brown, slightly silty, fine SAND
5.0
Fairly soft brown gray slightly sandy clayey SILT.
7.5
Fairly soft brownish gray slightly sandy silty CLAY.
11.0
Soft gray slightly clayey slightly sandy SILT
12.0
Soft gray slightly sandy silty CLAY.
17.0 EL. 209.6

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

RECORD OF FOUNDATION

EXPLORATION NO. 23

IN SHEETS	SHEET NO.	SCALE
		10 0 10 20

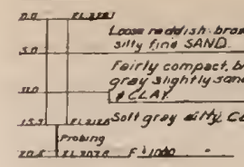
U.S. ENGINEER OFFICE, MASSENA, NEW YORK FEBRUARY 1942

DRAWN BY	RECOMMENDED	APPROVED
R.M. Harrison, ENGINEER	LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER	DIVISION ENGINEER

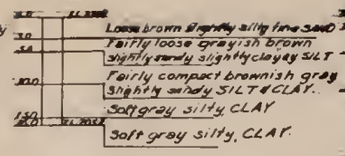
DRAWN BY: G.I.S. CHECKED BY: H.F. FILE NO. MC-A-2/36 TRANSMITTED WITH LETTER OR ENDORSEMENT DATED

PLATE III-27

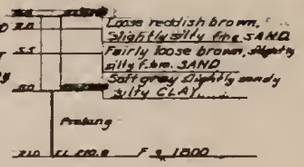
T1980a


Loose reddish brown, slightly silty fine SAND.
Fairly compact, brownish gray slightly sandy SILT & CLAY.
Soft gray silty CLAY.
Probing
F=1000

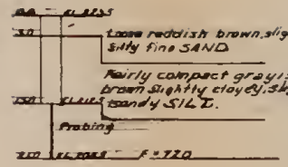
T1981a


Loose brown slightly silty fine SAND
Fairly loose grayish brown slightly sandy slightly clayey SILT
Fairly compact brownish gray slightly sandy SILT & CLAY.
Soft gray silty CLAY
Soft gray silty CLAY.

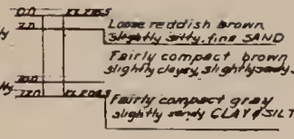
T1982a


Loose reddish brown, slightly silty fine SAND.
Fairly loose brown, slightly silty f.-m. SAND
Soft gray slightly sandy silty CLAY
Probing
F=1800

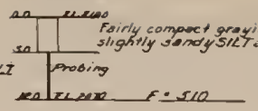
T1983a


Loose reddish brown, slightly silty fine SAND.
Fairly compact grayish brown slightly clayey, slightly sandy SILT.
Probing
F=720

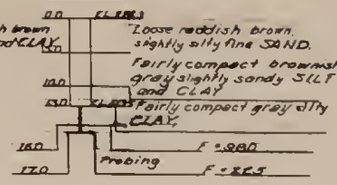
T1984a


Loose reddish brown, slightly silty fine SAND
Fairly compact brown slightly clayey, slightly sandy SILT
Fairly compact gray slightly sandy CLAY & SILT

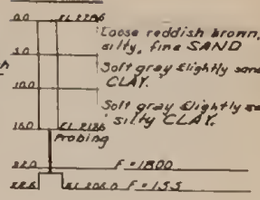
T1985a



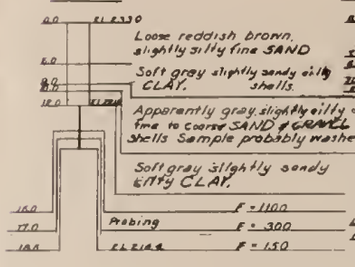
T1986a


Loose reddish brown, slightly silty fine SAND.
Fairly compact brownish gray slightly sandy SILT and CLAY
Fairly compact gray silty CLAY.
F=980
Probing
F=225

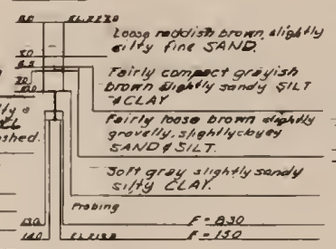
T1987a



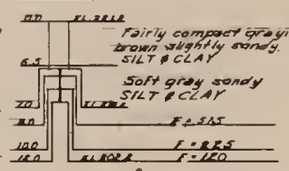
T1988a


Loose reddish brown, slightly silty fine SAND
Soft gray slightly sandy silty CLAY.
Shells
Apparently gray slightly silty fine to coarse SAND & GRAVEL Shells Sample probably washed.
Soft gray slightly sandy silty CLAY.
F=1100
Probing
F=300
F=150

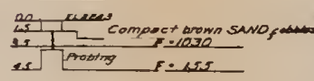
T1989a


Loose reddish brown, slightly silty fine SAND.
Fairly compact grayish brown slightly sandy SILT & CLAY
Fairly loose brown slightly gravelly, slightly clayey SAND & SILT.
Soft gray slightly sandy silty CLAY.
Probing
F=830
F=150

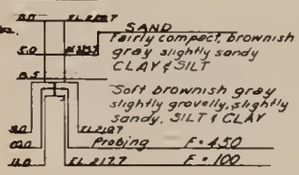
T1990a



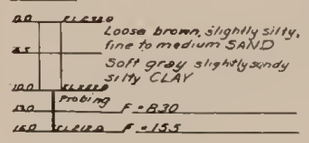
T1991a



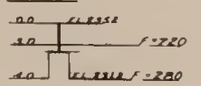
T1992a



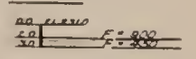
T1993a



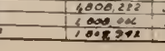
P1994



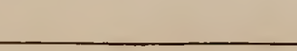
P1995



P1996



T1997a



T1998a

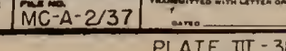
T1999a

P3000

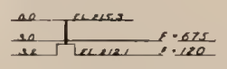
P3001

P3002

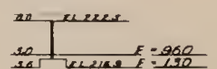
P3003



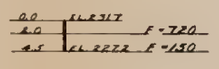
P3004



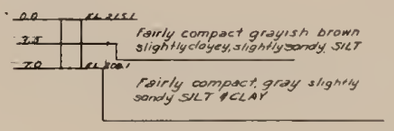
P3005



P3006



T3007a



NOTES:

Analyses of overburden are based on dry samples.
Elevations based on U.S.G.S. datum MSL 1912 adj.
F-000-a denotes 5" diameter hand auger holes to refusal or no recovery and extended by hand probing. Probing made with ¾" rod driven 14# sledge.
P-000 denotes hand probing only.
F. denotes rate of probing penetration in feet per hour.
See sheet File No MC-A-2/1 for descriptive terms

LOCATION OF HOLES BY TRANSVERSE MECATOR COORDINATES

HOLE NUMBER	NORTH	EAST
T1980a	1,808,481	337,804
T1981a	1,808,686	337,755
T1982a	1,808,485	337,511
T1983a	1,808,621	337,467
T1984a	1,808,915	337,418
T1985a	1,808,720	337,126
T1986a	1,808,558	337,173
T1987a	1,808,337	337,214
T1988a	1,808,285	337,028
T1989a	1,808,511	336,980
T1990a	1,808,726	336,961
T1991a	1,808,784	336,833
T1992a	1,808,[illegible]	336,698
T1993a	1,808,273	336,231
P1994	1,808,206	336,633
P1995	1,808,421	336,585
P1996	1,808,638	336,541
T1997a	1,808,571	336,848
T1998a	1,808,355	336,292
T1999a	1,808,133	336,341
P3000	1,808,034	336,191
P3001	1,808,473	336,048
P3002	1,808,283	335,999
P3003	1,808,685	335,935
P3004	1,808,340	335,695
P3005	1,808,282	335,707
P3006	1,808,064	335,751
T3007a	1,808,342	335,462

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
RECORD OF FOUNDATION
EXPLORATION NUMBER 24

SCALE 10 0 10 20

U.S. ENGINEER OFFICE, MASSENA, NEW YORK FEBRUARY 1942

SUBMITTED: R. M. Hamer, ENGINEER
RECOMMENDED: L. D. Butler, LT. COL. CORPS OF ENGINEERS
APPROVED: [illegible], COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: R.K.E.
FILE NO. MC-A-2/37
TRANSMITTED WITH LETTER OR ENDORSEMENT DATED

D-1151

0.0 EL 2136 — Soft, gray, slightly sandy, silty CLAY.

11.0 EL 2025

Soft gray CLAY

29.0 EL 1825 — Soft gray, slightly sandy CLAY

36.3 EL 1778 — Fairly loose, gray, silty

40.0 EL 1746 — gravelly SAND

D-1155

0.0 EL 2240 — Loose, brown, slightly sandy SILT

7.0 EL 2178

Loose, gray silty CLAY

14.0 EL 2090

19.0 EL 2056 — Compact, gray, slightly clayey, slightly gravelly SAND

Compact, gray, slightly clayey, slightly gravelly silty SAND

34.0 EL 1920 — Compact, gray, slightly gravelly, slightly silty SAND

43.0 EL 1818

D-1166

0.0 EL 2258 — Brown loose clayey silt

2.3 EL 2220.3

Brown loose slightly silty gravelly SAND.

26.8 EL 1990

Gray, compact, slightly gravelly, silty SAND

72.0 EL 1558

D-1167

0.0 EL 2184 — Grayish brown loose silty clay

5.0 EL 2134 — Gray fairly loose, silty gravelly SAND

17.0 EL 2014

Gray compact, slightly gravelly, slightly silty to silty SAND Occasional boulders

25.0 EL 1634

DOLOMITE, dark gray, hard Few shaly zones No indication of fracture or weathered zones.

69.0 EL 1494 — SHALE, black medium hard Rock apparently sound and unweathered

71.8 EL 1466

75.4 EL 1430 — DOLOMITE, dark grey, few thin beds of shale No indication of fracture or weathering

Core recovery 92.9 %

D-1168

0.0 EL 2152.4 — Soft, brownish gray to gray slightly sandy, slightly silty, CLAY

6.8 EL 2046 — Soft, grey, CLAY.

16.7 EL 1987

19.7 EL 1957 — Compact gray, slightly gravelly slightly sandy SILT & CLAY

Compact gray, slightly gravelly, silty to very silty SAND

43.9 EL 1655

Compact, gray, slightly gravelly, very silty SAND

63.6 EL 1518

68.5 EL 1469 — DOLOMITE, light gray, hard Broken along few 70° joints Rock apparently sound with no indication of weathering

71.0 EL 1444

SHALE, black, med hard, slight indication of weathering Rock apparently sound

88.0 EL 1314 — DOLOMITE, interbedded with occasional beds of shale and limestone. Rock broken along occasional joints and partings Rock apparently sound No indications of fractures or weathering

Core recovery 92.0 %

D-1169

0.0 EL 2127 — Grayish-brown, fairly loose SILT & CLAY

8.0 EL 2093.7 — Grayish-brown to gray, loose slightly silty to silty gravelly SAND.

26.7 EL 1910

Gray, compact slightly gravelly silty SAND

70.0 EL 1477

D-1170

0.0 EL 2248 — Brown, fairly compact slightly gravelly, silty SAND

7.0 EL 2178

Brown, fairly compact, slightly silty, gravelly SAND

22.0 EL 2048

Gray, compact, slightly gravelly, silty SAND occasional boulders

70.0 EL 1548

D-1171

0.0 EL 2167 — Loose, grayish-brown, silty CLAY

3.2 EL 2128

Loose, gray, CLAY

21.0 EL 1953

Fairly compact to compact, gray, very silty, gravelly SAND Occasional boulder

70.0 EL 1467

D-1172

0.0 EL 2121.4 — Soft, brownish gray, slightly sandy, silty, CLAY.

2.0 EL 2103.4 — Loose, gray, slightly gravelly clayey, very silty SAND

11.0 EL 1989

Soft gray, CLAY

18.6 EL 1924.9

Loose gray, slightly gravelly sandy, very clayey SILT.

38.3 EL 1747.9

Compact gray, slightly gravelly very silty, SAND.

70.0 EL 1401.4

D-1175

0.0 EL 1863 — Soft brownish gray, slightly sandy SILT & CLAY

8.0 EL 1818.2

Soft, gray CLAY

21.0 EL 1811.8 — Fairly soft, slightly clayey gravelly SAND & SILT

32.0 EL 1755.3

Fairly compact, slightly gravelly, silty SAND to SILT & SAND.

40.6 EL 1687

D-1177

0.0 EL 2127 — Soft brownish-gray, slightly sandy, very silty CLAY

6.0 EL 2121.7

Soft gray, slightly sandy, CLAY

19.2 EL 1936.5

23.0 EL 1893 — Fairly loose gray, slightly gravelly, sandy, very clayey SILT

22.0 EL 1887 — Fairly loose, gray, slightly gravelly, very silty SAND.

Compact, gray, slightly gravelly, very silty, SAND.

38.7 EL 1730

D-1178

9.8 EL 2195.8 — Loose, black, topsoil

Soft, brownish gray, silty CLAY.

10.0 EL 2085.8

Soft, gray, CLAY.

30.6 EL 1865.2

Compact, gray, slightly gravelly very silty, SAND.

47.2 EL 1686

Very compact, gray, gravelly, very silty, SAND.

70.5 EL 1653

D-1179

0.0 EL 2135

Soft, gray, CLAY.

Loose, gray, gravelly, very silty SAND.

30.8 EL 1773

Fairly compact, gray gravelly, very silty SAND.

43.6 EL 1717.2

D-1180

0.0 EL 2216.8 — Soft, brownish gray, slightly sandy CLAY & SILT.

10.0 EL 2006.8

Soft gray, CLAY

16.0 EL 2000.8

19.6 EL 1982.2 — Loose, gray, slightly sandy slightly gravelly CLAY.

Fairly loose, gray, slightly gravelly, very silty SAND

27.0 EL 1903.8

Compact, gray, slightly gravelly SAND & SILT.

37.6 EL 1792

D-1181

0.0 EL 2124.9 — Soft, gray, slightly clayey SILT

7.0 EL 2079.9

Soft gray, CLAY

46.2 EL 1936

49.7 EL 1902 — Fairly soft, gray, slightly sandy, silty, CLAY

51.6 EL 1883

Fairly loose, gray, gravelly very silty, SAND.

Compact, gray, gravelly silty to very silty SAND

61.8 EL 1733

D-1217

0.0 EL 2298 — Compact, brownish-grey SAND & SILT.

5.6 EL 2242

Compact, brownish-grey, gravelly, very silty SAND

14.0 EL 2158

Compact, grey, gravelly, very silty SAND

40.0 EL 1858

D-1218

0.0 EL 2244.8 — Fairly soft, brownish-gray, slightly sandy, SILT & CLAY

10.5 EL 2134.3

Loose, gray, slightly gravelly to gravelly very silty SAND

29.6 EL 1952

Compact, gray, gravelly, very silty SAND

40.0 EL 1836.8

D-1219

0.0 EL 2279.6 — Fairly loose, brownish gray, gravelly, silty to very silty, SAND.

6.0 EL 2223.6

8.0 EL 2221.6 — Fairly compact, brownish gray, gravelly, very silty SAND.

Fairly compact gray, gravelly, very silty SAND to SAND & SILT

29.5 EL 2100.1

Compact, gray, gravelly very silty, SAND.

40.3 EL 1833.3

D-1221

0.0 EL 2170 — Fairly compact, brownish grey, gravelly SAND & SILT

12.5 EL 2049 — Fairly compact, grey gravelly SAND & SILT.

19.5 EL 1975

Fairly loose, grey, gravelly, very sandy SILT.

40.0 EL 1777.0

D-1222

0.0 EL 2218.3 — Soft, brownish-gray, slightly sandy, SILT & CLAY.

9.8 EL 2093.3

Loose, brownish-gray gravelly, very silty SAND.

21.0 EL 1972

Fairly compact, gray, gravelly, very silty SAND.

34.0 EL 1882.3

Compact, gray, gravelly very silty SAND.

41.0 EL 1772.3

NOTES:

Analyses of overburden are based on dry samples.

Analyses of bed rock are based on 2⅛" rock cores obtained by drilling.

Holes numbered less than 01500 drilled with 3½" casing

Elevations based on U.S.G.S. datum M.S.L. 1912 adj.

See sheet file No. MC-A-1 for descriptive chronology

See sheet file No. MC-A-1 coordinates of holes.

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL - DIKES

RECORD OF FOUNDATION EXPLORATION NO. 25

IN SHEETS — SHEET NO. — SCALE 1" = 10 Ft

U.S. ENGINEER OFFICE, MASSENA, N.Y. FEBRUARY 1942

SUBMITTED: R. M. Hanna, ENGINEER

RECOMMENDED: HEAD OF DIVISION; LT. COL. CORPS OF ENGINEERS

APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: FHA CHECKED BY:

FILE NO. MC-A-2/38

TRANSMITTED WITH LETTER DA ENDORSEMENT DATED ---- 194

D-1223

0.0 EL 2288

Fairly compact, variable black to brown SAND & SILT.

7.5 EL 2213

Compact, variable brown to grey, slightly gravelly, slightly silty SAND.

24.4 EL 2063

Compact, grey, slightly gravelly silty SAND.

40.0 EL 1888

D-1224

0.0 EL 2272

Loose, gray-brown, sandy and gravelly SILT

8.0 EL 2192

Fairly compact, gray-brown, gravelly, slightly silty SAND 18.2

14.5 EL 2127

Compact, gray, variable silty and gravelly SAND with occasional boulders

25.0

48.5 EL 1887

D-1225

0.0 EL 2154

Soft, brownish-gray slightly sandy SILT & CLAY.

6.0 EL 2094

Loose, brown, slightly silty. SAND.

18.2 EL 2034

Soft, grey slightly sandy SILT & CLAY.

25.0 EL 1904

Fairly loose, to compact gray, gravelly, SAND & SILT.

70.0 EL 1454

D-1226

0.0 EL 2157

Fairly soft, brownish-gray slightly sandy, very clayey SILT

7.2 EL 2085

8.0 EL 2077 Loose, brown, slightly silty SAND

9.5 EL 2062

Soft, brownish-gray clayey, sandy, SILT

13.5 EL 2022

18.0 EL 1897 Loose, brownish-gray slightly silty, gravelly SAND

Fairly loose, gray, clayey gravelly, very sandy SILT

Soft, gray, CLAY.

30.2 EL 1655

Loose, gray, slightly gravelly SAND

35.0 EL 1807

37.7 EL 1780 Fairly compact, gray, very silty, very gravelly, SAND

Compact gray gravelly very silty, SAND

50.2 EL 1655

D-1227

0.0 EL 2241

Fairly compact, brownish grey, gravelly, silty to very silty SAND.

10.0 EL 2141

Compact, grey, slightly gravelly, silty SAND.

17.0 EL 2071

Fairly compact, grey slightly gravelly SAND & SILT.

40.5 EL 1836

D-1228

0.0 EL 2225

Compact, brown, silty gravelly SAND. Occasional boulders.

17.0 EL 2125

Compact, grey, gravelly very sandy SILT. Occasional boulders

40.9 EL 1884

D-1229

0.0 EL 2183

Fairly soft, brownish-grey clayey SAND & SILT

7.0 EL 2053

Soft, grey, slightly silty slightly sandy CLAY.

25.0 EL 1873

27.4 EL 1849 Compact, grey, gravelly, very sandy very silty CLAY.

Compact, grey, gravelly, very sandy SILT.

47.0 EL 1653

D-1230

0.0 EL 2108

Soft, brown-gray, slightly sandy SILT & CLAY.

7.0 EL 2038

Soft, gray, slightly sandy CLAY

33.0 EL 1778

Soft, gray, slightly sandy and gravelly CLAY.

43.8 EL 1637

43.4 EL 1633 Soft, gray, sandy, slightly gravelly CLAY

Fairly compact, gray, SAND SILT & GRAVEL

54.0 EL 1528

54.6 EL 1518 Very compact, gray, silty SAND & GRAVEL

D-1231

0.0 EL 2112

Soft, gray, sandy, very silty CLAY

6.0 EL 1962

Soft, gray, CLAY

31.0 EL 1812

35.0 EL 1772 Compact, gray, gravelly very silty SAND

37.0 EL 1752 Soft, gray, slightly gravelly, slightly sandy, very silty CLAY

42.1 EL 1691

Loose, gray, slightly silty gravelly SAND

Compact, gray, gravelly very sandy SILT

52.7 EL 1585

D-1232

0.0 EL 2262

3.3 EL 2229 Topsoil.

Loose, brown, slightly gravelly SAND. Apparently washed.

10.0 EL 2162

Fairly compact to compact, slightly gravelly, silty SAND.

40.0 EL 1862

D-1233

0.0 EL 2379

Loose, brown, slightly silty, slightly gravelly SAND. Shell fragments.

9.0 EL 2289

Fairly compact to compact, grey, slightly gravelly, silty SAND.

30.0 EL 2079

D-1234

0.0 EL 2355

Compact, brown, slightly gravelly, silty SAND.

13.0 EL 2225

Compact, grey, slightly silty, slightly gravelly, SAND. Occasional boulders.

32.0 EL 2035

D-1235

0.0 EL 2229

Fairly soft, brownish-grey, very clayey SILT.

9.0 EL 2139

Fairly soft, grey very silty CLAY.

17.0 EL 2059

Fairly soft, grey, slightly gravelly, very sandy, very clayey SILT.

28.0 EL 1949

Fairly compact, grey gravelly, very silty SAND.

50.0 EL 1729

D-1236

0.0 EL 218.8

Fairly compact, brownish-grey, clayey, very sandy SILT.

5.0 EL 207.8

Fairly loose, grey, gravelly SAND. Shell fragments

10.9 EL 202.3

Soft, grey slightly sandy CLAY.

28.0 EL 1848

29.5 EL 1833 Loose, grey, gravelly, very sandy, very clayey SILT

35.2 EL 1776 Apparently, loose grey, gravelly SAND.

Compact, grey, gravelly SAND & SILT.

50.6 EL 1623

D-1237

0.0 EL 1707

Loose, grey, gravelly, silty SAND

15.0 EL 1557

Loose, grey, slightly gravelly, slightly clayey SILT

22.0 EL 1487

26.0 EL 1447 Fairly loose, gray, variably gravelly, silty SAND

Fairly compact to compact, gravelly, very silty SAND. Occasional boulders.

35.3 EL 1340

37.0 EL 1320

DOLOMITE, hard, occasional thin beds and stringers of shale. Considerable calcite and pyrite throughout. Few small solution cavaties. Rock apparently sound

46.5 EL 1043 Core recovery 30.5%

D-1242

0.0 EL 209.5

Compact brownish grey slightly clayey SAND

0.3 EL 209.2 of SILT. Shells.

Soft grey silty CLAY with pockets or lenses of uniform fine to medium sand and mixtures of sand and clay. few lenses or pockets of soupy material and stiff clay.

Compact grey slightly silty SAND.

35.3 EL 174.0

37.0 EL 172.3

Variable soft to stiff grey CLAY with sand lenses.

44.5 EL 165.0

46.0 EL 163.5 Fairly compact grey slightly clayey SAND & SILT.

47.3 EL 162.2

Soft grey slightly sandy silty CLAY.

54.5 EL 154.8

Compact grey slightly clayey, slightly gravelly SAND & SILT Cobbles.

D1242A

0.0 EL. 209.5

Soft grey silty CLAY with pockets or lenses of uniform fine to medium sand and mixtures of sand and clay. Few lenses or pockets of soupy material and stiff clay.

33.4 EL 176.1

D1243

0.0 EL 214.8

Soft gray slightly sandy, silty CLAY.

7.2 EL 207.6

Soft grey, silty CLAY

37.7 EL 177.1

Compact grey slightly silty SAND.

39.5 EL 176.3

D1279

0.0 EL 216.4

Fairly compact grey slightly sandy SILT and CLAY.

10.1 EL 206.3

D1279A

0.0 EL. 216.4

Fairly compact to soft grey, slightly sandy SILT & CLAY Cobble at 12.5'

13.9 EL. 208.5

D1279B

0.0 EL. 216.4

Fairly compact to soft grey slightly sandy SILT & CLAY.

18.8 EL. 206.0 Soft grey variable slightly sandy SILT

19.0 EL. 198.4 & CLAY to loose CLAY & GRAVEL

D1399

0.0 EL 2262

Loose brown slightly silty SAND

8.0 EL 2182

Loose grey fine SAND

14.5 EL 2117

16.0 EL 2102 Soft grey slightly sandy silty CLAY

Loose grey slightly clayey fine

21.3 EL 2047 SAND & SILT.

Soft grey silty CLAY

50.8 EL 1754

NOTES:

Analyses of overburden are based on dry samples

Analyses of bed rock are based on 2⅛ rock cores obtained by drilling. Holes numbered less than D1500 drilled with 2½ casing.

See sheet File No. MCA-1/4 for descriptive terms.

See sheet File No. MCA-1/1 for coordinates of holes.

Elevations based on U.S.G.S datum M.S.L. 1912 adj.

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL DIKES

RECORD OF FOUNDATION, EXPLORATION NO. 26

IN SHEETS | SHEET NO. | SCALE 1"=10 Ft.

10 0 10 20

U.S. ENGINEER OFFICE, MASSENA, N.Y. FEBRUARY, 1942

SUBMITTED: O. R. M. Hanna, ENGINEER

RECOMMENDED: [illegible], CHIEF OF DIVISION

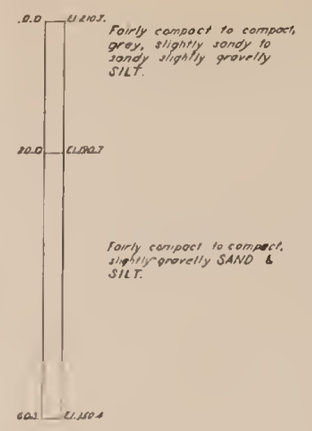
APPROVED: [illegible], COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: T.M.A. CHECKED BY: L.M.W.

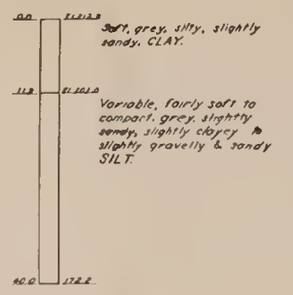
FILE NO. MC-A-2/39

TRANSMITTED WITH LETTER OR ENDORSEMENT DATED ---------- 1941

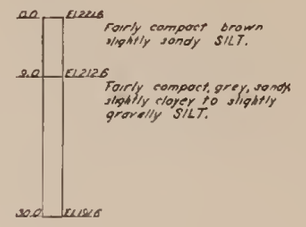
D-2000


0.0 El 2107.
Fairly compact to compact, grey, slightly sandy to sandy slightly gravelly SILT.
20.0 El 1907
Fairly compact to compact, slightly gravelly SAND & SILT.
60.1 El. 1504

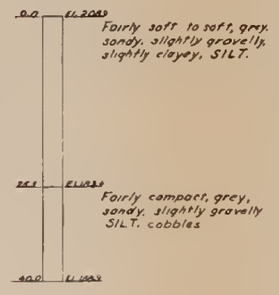
D-2001


0.0 El 2123.9
Soft, grey, silty, slightly sandy, CLAY.
11.9 El 2112.0
Variable, fairly soft to compact, grey, slightly sandy, slightly clayey & slightly gravelly & sandy SILT.
40.0 1972.2

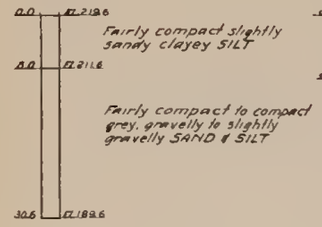
D-2002


0.0 El 2216
Fairly compact brown slightly sandy SILT.
9.0 El 2126
Fairly compact, grey, sandy slightly clayey to slightly gravelly SILT.
30.0 El 1926

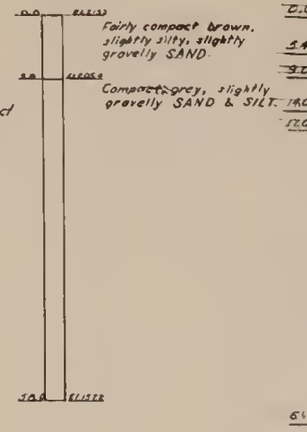
D-2003


0.0 El 2083
Fairly soft to soft, grey, sandy, slightly gravelly, slightly clayey, SILT.
22.1 El 1983
Fairly compact, grey, sandy, slightly gravelly SILT. cobbles
40.0 El 1965

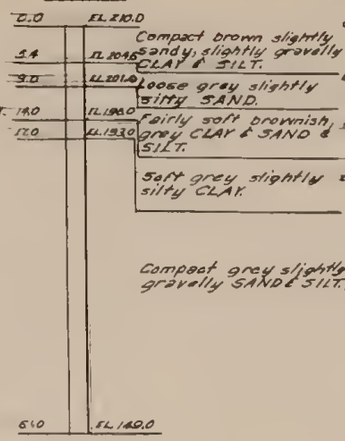
D-2004


0.0 El 2136
Fairly compact slightly sandy clayey SILT
8.0 El 2116
Fairly compact to compact grey, gravelly to slightly gravelly SAND & SILT
30.6 El 1892.6

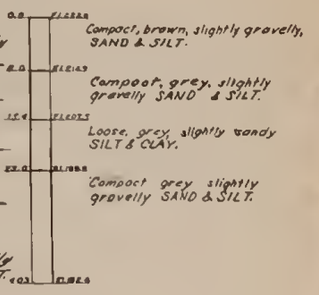
D-2005


0.0 El 2133
Fairly compact brown, slightly silty, slightly gravelly SAND.
8.0 El 2058
Compact grey, slightly gravelly SAND & SILT.
30.8 El 1733

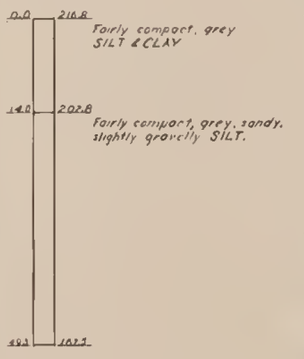
D-2006


0.0 EL 2110.0
Compact brown slightly sandy, slightly gravelly CLAY & SILT.
5.4 EL 2045
3.0 EL 2010
Loose grey slightly silty SAND.
14.0 EL 1960
17.0 EL 1930
Fairly soft brownish grey CLAY & SAND & SILT.
Soft grey slightly silty CLAY.
Compact grey slightly gravelly SAND & SILT.
61.0 EL 1460

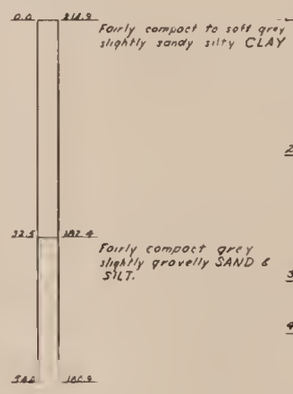
D-2007


0.0 El 2128.8
Compact, brown, slightly gravelly, SAND & SILT.
8.0 El 2108.3
Compact, grey, slightly gravelly SAND & SILT.
15.0 El 2101.5
Loose, grey, slightly sandy SILT & CLAY.
22.0 El 1988.8
Compact grey slightly gravelly SAND & SILT.
El 1982.6

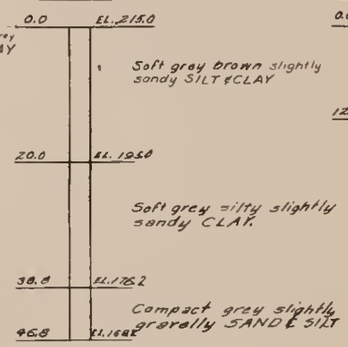
D-2008



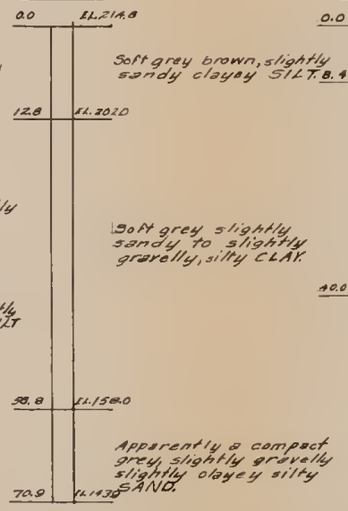
D-2009


0.0 211.3
Fairly compact to soft grey, slightly sandy silty CLAY
22.5 192.4
Fairly compact grey slightly gravelly SAND & SILT.
34.2 180.9

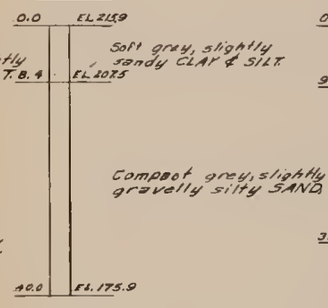
D2010


0.0 EL. 215.0
Soft grey brown slightly sandy SILT & CLAY
20.0 EL. 195.0
Soft grey silty slightly sandy CLAY.
38.8 EL. 176.2
Compact grey slightly gravelly SAND & SILT
46.8 EL. 168.2

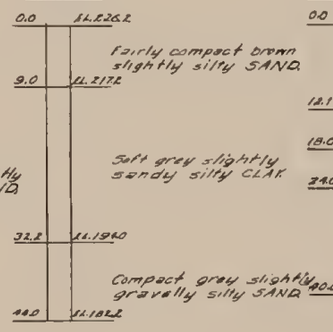
D.2011


0.0 EL. 214.8
Soft grey brown, slightly sandy clayey SILT.
12.8 EL. 202.0
Soft grey slightly sandy to slightly gravelly, silty CLAY.
58.8 EL. 156.0
Apparently a compact grey, slightly gravelly slightly clayey silty SAND.
70.9 EL. 143.9

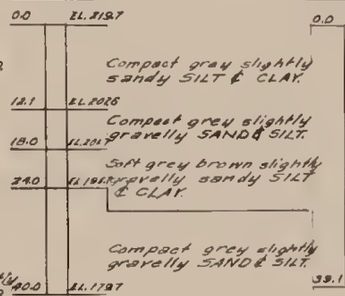
D 2012



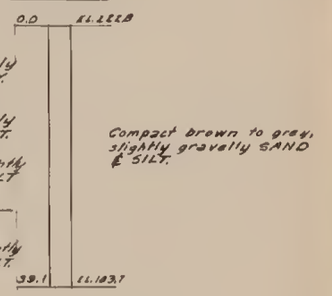
D2013


0.0 EL 226.2
Fairly compact brown slightly silty SAND.
9.0 EL. 217.2
Soft gray slightly sandy silty CLAY.
32.2 EL. 194.0
Compact grey slightly gravelly silty SAND
44.0 EL. 182.2

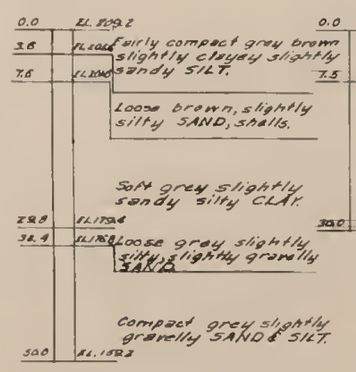
D2014


0.0 EL. 219.7
Compact gray slightly sandy SILT & CLAY.
18.1 EL. 202.6
Compact grey slightly gravelly SAND & SILT.
18.0 EL. 201.7
Soft grey brown slightly gravelly sandy SILT & CLAY.
24.0 EL. 195.7
Compact grey slightly gravelly SAND & SILT.
40.0 EL. 179.7

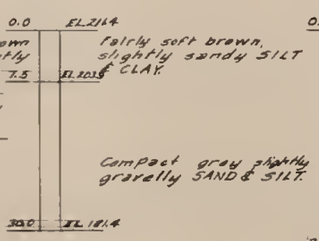
D2015



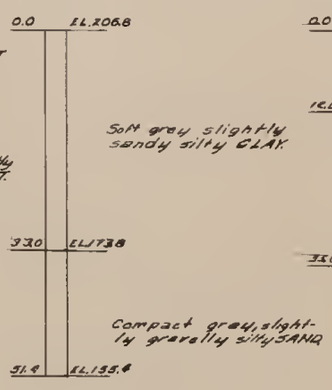
D2016


0.0 EL. 209.2
3.6 EL. 205.6
Fairly compact grey brown slightly clayey slightly sandy SILT.
7.6 EL. 201.6
Loose brown, slightly silty SAND, shells.
Soft grey slightly sandy silty CLAY.
29.8 EL. 179.4
34.4 EL. 174.8
Loose grey slightly silty, slightly gravelly SAND.
Compact grey slightly gravelly SAND & SILT.
50.0 EL. 159.3

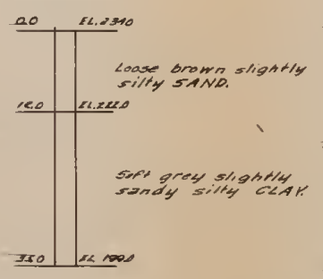
D2017



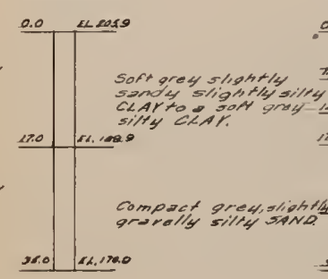
D2018



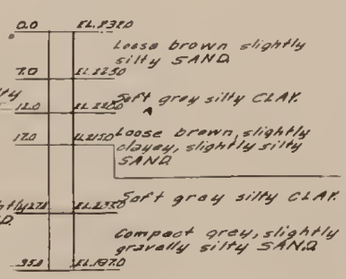
D2019



D2020


0.0 EL. 205.9
Soft grey slightly sandy slightly silty CLAY to a soft grey silty CLAY.
17.0 EL. 188.9
Compact grey, slightly gravelly silty SAND.
38.0 EL. 176.0

D2021


0.0 EL. 231.0
Loose brown slightly silty SAND.
7.0 EL. 224.0
Soft grey silty CLAY.
11.0 EL. 220.0
17.0 EL. 214.0
Loose brown, slightly clayey, slightly silty SAND.
Soft gray silty CLAY.
Compact grey, slightly gravelly SAND.
35.3 EL. 193.0

NOTES:

Analyses of overburden are based on dry samples.
Analyses of bed rock are based on 2⅛ Fock cores obtained by drilling.
Elevations are based on U.S.G.S. datum, M.S.L. 1912 adj.
Holes numbered less than D1500 drilled with 3⅛" casing.
Holes numbered greater than D1500 drilled with 2½" casing.
See sheet File No. MC-A-1/4 for descriptive terms.
See sheet File No. MC-A-1/4 for coordinates of holes.

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL - DIKES

RECORD OF FOUNDATION

EXPLORATION NUMBER 27

IN SHEETS	SHEET NO.	SCALE
		10 0 10 20

U. S. ENGINEER OFFICE, MASSENA, NEW YORK — FEBRUARY 1942

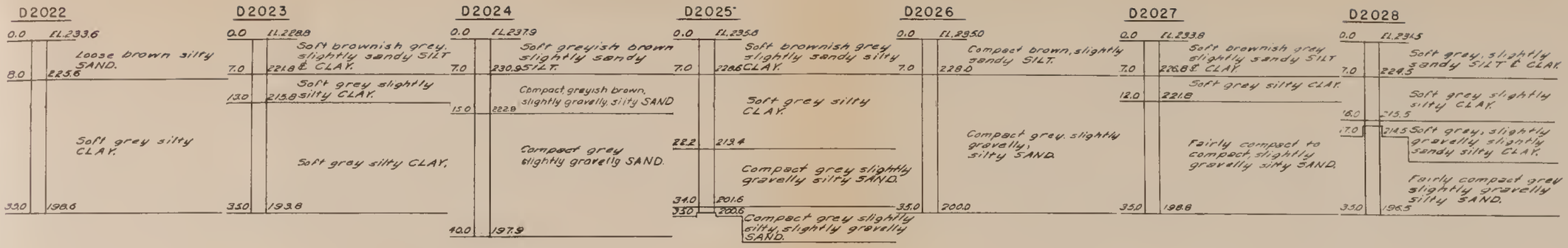
SUBMITTED: R. M. Hames, ENGINEER

RECOMMENDED: [signature], [signature], Lt. Col., CORPS OF ENGINEERS

APPROVED: [signature], DIVISION ENGINEER, DISTRICT ENGINEER

DRAWN BY: CHECKED BY: FILE NO. MC-A-2/40 TRANSMITTED WITH LETTER OF ENDORSEMENT DATED _____ INT.

PLATE III-41



NOTES:

Analyses of overburden are based on dry samples.
Analyses of bed rock are based on 2⅛" rock cores obtained by drilling.
Elevations based on U.S.G.S. datum M.S.L. 1912(4)
Holes numbered less than D1500 drilled with 3½" casing.
Holes numbered greater than D1500 drilled with 2½" casing.
See sheet File No. MCA 3/4 for descriptive terms.
See sheet File No MCA 3/4 for coordinates of holes.

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL DIKES

RECORD OF FOUNDATION EXPLORATION

NO. 28

IN SHEETS | SHEET NO. | SCALE 1"=10' VERTICAL

U S ENGINEER OFFICE, MASSENA, NEW YORK — FEBRUARY 1942

SUBMITTED: R. M. Hamer, ENGINEER

RECOMMENDED: [signature], ASST ENGR; [signature], LT. COL. CORPS OF ENGINEERS

APPROVED: [signature], COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY R E B. | TRACED BY | CHECKED BY | FILE NO MC-A-2/41 | TRANSMITTED WITH LETTER OR ENDORSEMENT DATED _____ 19__

ST. LAWRENCE RIVER

PROBING RESULTS - LONG SAULT CANAL, BIKE #1

Porbing No. Coordinates and Surface Elevation	Depth in Feet	Blows per Foot	Samples No.	Samples Depth	Description of Samples
PH-4668					
N. 1,812,601	0-14	5	S1	7.6	Silty SAND (Shells)
E. 358,547	14-23	20	S2	13.6	Sandy, silty CLAY
EL. 216.9	23-24	61	S3	19.6	SILT & CLAY
	24-25	108			
	25-26	231			
	No Refusal				
PH-4669					
N. 1,812,539	0-6	3	S1	7.6	Silty CLAY
E. 358,253	6-20	7	S2	13.6	Silty CLAY
EL. 216.9	20-22	36	S3	20.4	SAND & GRAVEL
	22-25	15			
	25-36	24			
	36-37	45			
	37-39	64			
	39-39.5	90			
	Refusal				
PH-4670					
N. 1,812,476	0-11	3	S1	13.6	Silty SAND
E. 375,960	11-17	25	S2	20.6	Silty SAND
EL. 217.4	17-23	35			
	23-24	94			
	24-25	136			
	25-26	217			
	No Refusal				
PH-4671					
N. 1,812,413	0-15	5	S1	7.6	SILT & CLAY
E. 357,567	15-16	41	S2	13.6	Silty CLAY
EL. 218.0	16-16.5	68			
	Refusal				
PH-4672					
N. 1,812,350	0-1	2			
E. 357,373	1-3	6			
EL. 219.7	3-4	40			
	5-5.9	260			
	No Refusal				
PH-4673					
N. 1,812,287	0-7	4	S1	7.6	Sandy SILT & CLAY
E. 357,080	7-8	16	S2	13.6	Silty SAND
EL. 220.5	8-10	72			
	10-18	40			
	18-18.4	50			
	Refusal				
PH-4674					
N. 1,812,224	0-8	5	S1	7.6	Silty CLAY
E. 356,787	8-10	9	S2	13.6	Silty CLAY
EL. 218.5	10-29	6	S3	20.6	Silty CLAY
	29-30	35	S4	27.6	Silty CLAY
	30-33	66			
	33-33.6	185			
	Refusal				
PH-4675					
N. 1,812,161	0-20	6	S1	13.6	Silty CLAY
E. 356,493	20-25	31			
EL. 218.6	25-25.6	30			
	Refusal				
PH-4676					
N. 1,812,099	0-7	4	S1	7.6	SILT & CLAY
E. 356,200	7-10	10	S2	13.6	Silty CLAY
EL. 218.4	10-20	7			
	20-21	48			
	21-21.2	50			
	Refusal				
PH-4677					
N. 1,812,036	0-26	5	S1	7.6	Silty SAND
E. 355,907	26-27	24	S2	13.6	Silty CLAY
EL. 219.2	27-28	40	S3	20.6	Silty CLAY
	28-28.6	126	S4	26.6	SAND
	Refusal				
PH-4678					
N. 1,811,973	0-7	6	S1	7.6	SAND
E. 355,613	7-10	39	S2	13.6	Silty SAND
EL. 220.0	10-14	23			
	14-19	32			
	19-19.9	75			
	Refusal				
PH-4679					
N. 1,811,910	0-5	6	S1	7.6	Sandy, CLAY & SILT
E. 355,320	5-7	20			
EL. 223.8	7-8	53			
	8-9	98			
	9-10	138			
	10-11	139			
	No Refusal				
PH-4680					
N. 1,811,110	0-7	5	S1	7.6	Sandy SILT & CLAY
E. 353,100	7-11	9	S2	13.6	Silty SAND
EL. 226.9	11-15	7			
	15-16	33			
	16-17	69			
	17-17.4	52			

Porbing No. Coordinates and Surface Elevation	Depth in Feet	Blows per Foot	Samples No.	Samples Depth	Description of Samples
PH-4681					
N. 1,811,309	0-15	5	S1	7.6	Silty CLAY
E. 353,079	15-16	15	S2	13.6	Silty CLAY
EL. 227.1	16-17	59	S3	20.6	SAND
	17-22	37			
	22-24	97			
	24-25	211			
	No Refusal				
PH-4682					
N. 1,811,508	0-31	4	S1	7.6	Silty SAND
E. 353,058	31-34	36	S2	13.6	Silty CLAY
EL. 226.2	34-35	52	S3	20.6	Silty CLAY
	35-37	30	S4	26.6	Silty CLAY
	37-38	108			
	38-39	255			
	No Refusal				
PH-4683					
N. 1,811,079	0-8	4	S1	7.6	SILT & CLAY
E. 352,802	8-11	12	S2	13.6	Silty SAND
EL. 227.6	11-14	33			
	14-15	117			
	15-15.5	402			
	No Refusal				
PH-4684					
N. 1,811,278	0-13	4	S1	7.6	Sandy, SILTY CLAY
E. 352,781			S2	13.6	Silty CLAY
EL. 226.8	13-17	26			
	17-17.8	80			
	Refusal				
PH-4685					
N. 1,811,477	0-30	5	S1	7.6	Silty SAND
E. 352,760	30-35	22	S2	13.6	Silty CLAY
EL. 227.0	35-36	55	S3	19.6	Silty CLAY
	36-36.3	143	S4	26.6	Silty CLAY
	Refusal		S5	32.6	Sandy SILT & CLAY
PH-4686					
N. 1,811,048	0-18	4	S1	13.6	Silty CLAY
E. 352,503	18-19	60			
EL. 226.4	19-19.5	124			
	Refusal				
PH-4687					
N. 1,811,346	0-33	4	S1	13.6	Silty CLAY
E. 352,482	33-36	24	S2	25.6	Silty CLAY
226.2	36-37	84			
	37-38	179			
	No Refusal				
PH-4688					
N. 1,811,445	0-8	4	S1	7.6	Silty SAND
E. 352,462	8-11	13	S2	13.6	Silty SAND
EL. 227.2	11-40	6	S3	19.6	Silty CLAY
	40-53	14	S4	26.6	Sandy & Clayey SILT
	53-54	27	S5	33.6	Sandy SILT & CLAY
	54-55	50	S6	39.6	Silty CLAY
	55-56	77	S7	53.6	Silty CLAY
	56-58	44			
	58-59	122			
	No Refusal				
PH-4689					
N. 1,811,016	0-11	4			
E. 352,205	11-12	32			
EL. 226.6	12-12.5	30			
	Refusal				
PH-4690					
N. 1,811,215	0-15	8	S1	13.6	Silty SAND
E. 352,184					
EL. 227.8	15-27	5	S2	27.6	Clayey & Silty SAND
	27-36	9			
	36-38	25			
	38-39	51			
	39-39.8	110			
	Refusal				
PH-4691					
N. 1,811,414	0-47	7	S1	13.6	Silty SAND
E. 352,163	47-48	56	S2	26.6	Silty CLAY
EL. 227.5	48-48.2	75	S3	39.6	Silty CLAY
	Refusal				
PH-4692					
N. 1,810,985	0-4	3	S1	13.6	Silty SAND
E. 351,907	4-19	11	S2	27.6	Silty CLAY
EL. 226.7	19-63	6	S3	40.6	Sandy SILT
	63-64	61	S4	54.6	Sandy, Clayey SILT
	64-65	40			
	65-67	64			
	No Refusal				
PH-4693					
N. 1,811,184	0-77	6	S1	13.6	Silty SAND
E. 351,886	77-79	48	S2	26.6	Silty SAND
EL. 226.8	79-80	80	S3	40.6	Silty CLAY
	No Refusal		S4	53.6	Sandy, Silty CLAY

FILE NO. MC-A-2 /42
PLATE III - 43

ST. LAWRENCE RIVER

PROBING RESULTS - LONG SAULT CANAL, DIKE #1

Probing No. Coordinates and Surface Elevation	Depth in Feet	Blows per Foot	Samples No.	Samples Depth	Description of Samples
PH-4694					
N. 1,811,383	0-2	4	S1	13.6	Sandy, Silty CLAY
E. 351,865	2-5	11	S2	27.6	Silty CLAY
El. 227.4	5-29	6	S3	41.6	Silty CLAY
	29-31	13			
	31-61	6			
	61-66	14			
	66-82	21			
	82-85	48			
	85-85.6	30			
	Refusal				
PH-4695					
N. 1,811,168	0-2	2	S1	13.6	Silty SAND
E. 351,736	2-4	7	S2	27.6	Silty SAND
El. 227.5	4-39	4	S3	41.4	SAND
	39-40	37			
	40-41	51			
	41-42	67			
	42-43	99			
	No Refusal				
PH-4696					
N. 1,811,153	0-2	3	S1	13.6	Silty CLAY
E. 351,587	2-5	10	S2	20.2	SAND
El. 228.3	5-7	3			
	7-11	10			
	11-15	4			
	15-17	8			
	17-18	27			
	18-19	70			
	19-20	57			
	20-20.2	340			
	Refusal				
PH-4697					
N. 1,811,352	0-2	4	S1	13.6	Silty CLAY
E. 351,567	2-4	13	S2	27.6	Silty CLAY
El. 228.3	4-9	5	S3	31.4	SAND
	9-11	15	S4	34.4	Silty SAND
	11-28	5			
	28-29	15			
	29-32	52			
	32-35	187			
	35-36	155			
	36-37	381			
	No Refusal				
PH-4698					
N. 1,811,372	0-2	4	S1	13.6	SAND
E. 351,765	2-4	10	S2	40.6	Silty SAND
El. 227.6	4-6	4			
	6-7	12			
	7-10	8			
	10-14	4			
	14-15	10			
	15-50	5			
	50-59	11			
	59-59.5	24			
	Refusal				
PH-4699					
N. 1,811,398	0-3	4	S1	13.6	Silty SAND
E. 352,014	3-18	6	S2	40.6	Silty CLAY
El. 226.1	18-26	4	S3	54.6	Silty CLAY
	26-41	5			
	41-75	8			
	75-77	11			
	77-78	18			
	78-82	28			
	82-82.9	30			
	Refusal				
PH-4700					
N. 1,811,406	0-11	5	S1	27.6	Silty CLAY
E. 352,088	11-17	9	S2	47.6	Silty CLAY
El. 227.7	17-42	5			
	42-50	10			
	50-51	28			
	51-51.9	37			
	Refusal				
PH-4701					
N. 1,811,142	0-3	3	S1	13.4	Silty SAND
E. 351,488	3-12	5			
El. 220.6	12-13	22			
	13-14	59			
	14-15	105			
	15-16	97			
	16-17	205			
PH-4702					
N. 1,811,341	0-7	3	S1	13.4	SAND
E. 351,467	7-12	8			
El. 219.5	12-14	53			
	14-15	47			
	15-16	126			
	16-17	247			
	No Refusal				

Probing No. Coordinates and Surface Elevation	Depth in Feet	Blows per Foot	Samples No.	Samples Depth	Description of Samples
PH-4703					
N. 1,810,938	0-3	3			
E. 351,459	3-7	6			
El. 219.8	7-8	11			
	8-10	4			
	10-11	7			
	11-11.5	60			
	Refusal				
PH-4704					
N. 1,811,137	0-1	2			
E. 351,438	1-3	4			
El. 216.0	3-7	2			
	7-8.8	250			
	No Refusal				
PH-4705					
N. 1,811,336	0-6	3600	S1	7.4	Gravelly SAND
E. 351,437	6-7	14	S2	13.4	SAND
El. 213.8	7-13	27			
	13-15	51			
	15-17	40			
	17-18	113			
	18-18.6	370			
	No Refusal				
PH-4706					
N. 1,811,199	0-2	3	S1	20.6	Silty CLAY
E. 352,035	2-7	9	S2	41.6	Silty CLAY
El. 226.7	7-17	5	S3	54.6	Silty CLAY
	17-43	4			
	43-55	9			
	55-58	15			
	58-58.4	88			
	Refusal				
PH-4707					
N. 1,811,000	0-2	5	S1	13.6	Silty CLAY
E. 352,056	2-7	8	S2	27.6	Silty CLAY
El. 226.7	7-9	4			
	9-11	9			
	11-27	4			
	27-28	24			
	28-30	47			
	Refusal				
PH-4708					
N. 1,810,995	0-2	3	S1	20.6	Silty CLAY
E. 352,006	2-5	12	S2	40.6	Silty CLAY
El. 226.7	5-9	3			
	9-10	16			
	10-16	6			
	16-17	13			
	17-47	5			
	47-50	11			
	50-51	27			
	51-53	16			
	53-54	102			
	No Refusal				
PH-4709					
N. 1,811,173	0-3	2	S1	20.6	Sandy, Silty CLAY
E. 351,786	3-6	6	S2	40.6	Silty CLAY
El. 227.6	6-9	7	S3	47.6	Sandy, Silty CLAY
	9-41	4			
	41-48	7			
	48-52	9			
	52-53	35			
	53-53.4	40			
	Refusal				
PH-4710					
N. 1,810,970	0-2	3	S1	13.6	Silty SAND
E. 351,762	2-3	8	S2	27.6	Silty SAND
El. 227.1	3-5	14			
	5-15	6			
	15-36	4			
	36-37	20			
	37-38	50			
	38-39	75			
	Refusal				
PH-4711					
N. 1,810,974	0-2	2	S1	20.6	Silty SAND
E. 351,807	2-6	6	S2	40.6	Silty CLAY
El. 228.3	6-9	10			
	9-13	3			
	13-17	8			
	17-41	4			
	41-48	7			
	48-49	12			
	49-49.5	34			
	Refusal				
PH-4712					
N. 1,810,610	0-2	4	S1	20.6	Sandy, Silty CLAY
E. 351,790	2-7	6	S2	34.6	Sandy, Silty CLAY
El. 226.5	7-9	9	S3	47.6	Sandy, Silty CLAY
	9-10	5			
	10-12	7			
	12-47	4			
	47-49	15			
	49-50	27			
	50-50.2	35			

FILE NO. MC-A-2/43
PLATE III-44

ST LAWRENCE RIVER

PROBING RESULTS – LONG SAULT CANAL DIKE #1

Probing No. Coordinates and Surface Elevation	Depth in Feet	Blows per Foot	Samples No.	Samples Depth	Description of Samples
PR-4715					
N. 1,610,550	0-5	4	S1	[illegible]	SAND
E. 351,962	5-9	7			
EL. 224.6	9-19	4			
	19-20	16			
	20-21	47			
	21-23	30			
	23-23.6	35			
	Refusal				
PR-4716					
N. 1,610,642	0-2	3	S1	20.6	Silty SAND
E. 351,785	2-3	13			
EL. 227.5	3-7	5			
	7-10	9			
	10-24	4			
	24-25	12			
	25-26	22			
	26-27	10			
	27-29	26			
	29-31	21			
	31-31.3	23			
	Refusal				

FILE NO. MC-A-2/44
PLATE III-45

ST LAWRENCE RIVER

PROBING RESULTS - LONG SAULT CANAL, DIKE #3

Probing No. Coordinates and Surface Elevation	Depth in Feet	Blows per Foot	Samples No.	Samples Depth	Description of Samples
PR-4493					
N. 1,811,937	0-53	5	S1	7.6	Sandy SILT
E. 359,950	53-54	58	S2	13.6	Silty CLAY
EL. 214.9	54-55	180	S3	20.6	Silty CLAY
	No Refusal		S4	26.6	Silty CLAY
			S5	32.6	Silty CLAY
			S6	39.6	Silty CLAY
			S7	45.6	Silty CLAY
PR-4494					
N. 1,811,987	0-31	4	S1	20.6	SILT & CLAY
E. 359,863	31-60	6	S2	26.6	Silty CLAY
EL. 214.7	60-69	14	S3	32.6	Silty CLAY
	69-70	64	S4	39.6	Silty CLAY
	70-71	101	S5	45.6	Silty CLAY
	71-72	206			
	No Refusal				
PR-4495					
N. 1,812,036	0-30	4	S1	7.6	SAND & SILT
E. 359,776	30-50	7	S2	13.6	Silty CLAY
EL. 215.1	50-51	12	S3	26.6	Silty CLAY
	51-53	100	S4	32.6	Silty CLAY
	53-55	76	S5	39.6	Silty CLAY
	55-59	32			
	59-60	206			
	No Refusal				
PR-4496					
N. 1,812,286	0-40	5	S1	7.6	Silty SAND
E. 360,147	40-51	27	S2	13.6	Silty CLAY
EL. 214.8	51-53	48	S3	18.6	Silty CLAY
	53-54	175	S4	24.6	Silty CLAY
	No Refusal		S5	31.6	Silty CLAY
			S6	37.6	Silty CLAY
			S7	44.6	SAND
PR-4497					
N. 1,812,335	0-36	5	S1	7.6	Silty SAND
E. 360,059	36-37	82	S2	13.6	Silty CLAY
EL. 214.5	37-48	30	S3	20.6	Silty CLAY
	48-50	67	S4	26.6	Silty CLAY
	50-51	214	S5	32.6	Silty CLAY
	No Refusal		S6	39.6	Silty SAND
			S7	46.6	Sandy CLAY & SILT
PR-4498					
N. 1,812,384	0-36	6	S1	7.6	Silty CLAY
E. 359,972	36-38	39	S2	13.6	Silty CLAY
EL. 214.8	38-39	263	S3	20.6	Silty CLAY
	39-45	51	S4	26.6	Silty CLAY
	45-46	170	S5	32.6	Silty CLAY
	No Refusal				
PR-4499					
N. 1,812,112	0-43	4	S1	13.6	Silty CLAY
E. 360,048	43-56	14	S2	20.6	Silty CLAY
EL. 214.8	56-57	95	S3	26.6	Silty CLAY
	57-57.3	403	S4	33.6	Silty CLAY
	Refusal		S5	39.6	Silty CLAY
PR-4500					
N. 1,812,210	0-38	4	S1	7.6	Silty CLAY
E. 359,674	38-38.6	664	S2	13.6	Silty CLAY
EL. 215.0	No Refusal		S3	20.6	Silty CLAY
			S4	26.6	Silty CLAY
			S5	32.6	Silty CLAY
PR-4558					
N. 1,811,801	0-25	6	S1	13.6	SILT & CLAY
E. 359,988	25-31	21	S2	26.6	SAND
EL. 216.0	31-33	47			
	33-34	71			
	34-34.5	190			
	Refusal				
PR-4559					
N. 1,811,850	0-44	4	S1	13.6	SILT & CLAY
E. 359,901	44-45	15	S2	26.6	SILT & CLAY
EL. 214.9	45-46	37	S3	33.6	SILT & CLAY
	46-47	223			
	No Refusal				
PR-4560					
N. 1,812,310	0-7	2	S1	13.6	SILT & SAND
E. 360,103	7-11	8	S2	26.6	SILT & CLAY
EL. 214.7	11-47	4	S3	39.6	Sandy SILT & CLAY
	47-50	8			
	50-52	20			
	52-57	9			
	57-62	4			
	62-62.9	112			
	Refusal				
PR-4561					
N. 1,811,899	0-37	3	S1	13.6	Silty CLAY
E. 359,814	37-66	10	S2	27.6	SILT & CLAY
EL. 214.9	66-69	12	S3	40.6	Silty CLAY
	69-70	58	S4	54.6	SILT & CLAY
	70-71	120	S5	67.6	SAND
	71-72	265			
	No Refusal				

Probing No. Coordinates and Surface Elevation	Depth in Feet	Blows per Foot	Samples No.	Samples Depth	Description of Samples
PR-4562					
N. 1,812,291	0-10	5	S1	13.6	SILT & CLAY
E. 360,035	10-38	3	S2	26.6	Silty CLAY
EL. 214.7	38-39	32			
	39-42	79			
	42-46	26			
	46-46.6	35			
	Refusal				
PR-4563					
N. 1,812,379	0-21	3	S1	7.6	Sandy SILT
E. 360,084	21-30	4	S2	13.6	SILT & CLAY
EL. 214.9	30-32	91	S3	20.6	SILT & CLAY
	32-34	54	S4	26.6	Silty CLAY
	34-35	84	S5	31.4	Silty SAND
	35-38	71	S6	40.0	Silty SAND
	38-39	104	S7	60.6	Clayey SAND & SILT
	39-45	37	S8	62.7	Silty SAND
	45-47	60			
	47-48	45			
	48-53	34			
	53-57	58			
	57-62	29			
	62-62.7	114			
	Refusal				
PR-4564					
N. 1,812,359	0--3	4	S1	13.6	SILT & CLAY
E. 360,016	3-34	3	S2	26.6	SILT & CLAY
EL. 214.6	34-34.7	440			
	Refusal				
PR-4565					
N. 1,811,949	0-6	2	S1	13.6	SILTy CLAY
E. 359,727	6-13	4	S2	27.6	Silty CLAY
EL. 214.7	13-34	3	S3	40.6	Silty CLAY
	34-54	5	S4	54.6	SAND
	54-57	13			
	57-58	23			
	58-59	48			
	59-60	208			
	Refusal				
PR-4566					
N. 1,811,998	0-5	3	S1	13.6	Silty CLAY
E. 359,640	5-40	5	S2	27.6	SILT & CLAY
EL. 215.1	40-56	17	S3	40.6	SILT & CLAY
	56-58	37	S4	47.6	Silty CLAY
	58-59	17			
	59-60	45			
	60-60.7	70			
	Refusal				
PR-4567					
N. 1,812,134	0-11	5	S1	13.6	Silty CLAY
E. 359,602	11-22	4	S2	26.6	Silty CLAY
EL. 215.0	22-41	7	S3	33.6	Silty CLAY
	41-50	11	S4	46.6	Silty CLAY
	50-51	105			
	51-55	27			
	55-56	92			
	56-57	148			
	57-58	287			
	No Refusal				
PR-4568					
N. 1,812,482	0-9	3	S1	13.6	Silty CLAY
E. 359,798	9-36	5	S2	26.6	Silty CLAY
EL. 214.9	36-36.3	170			
	Refusal				
PR-4569					
N. 1,812,232	0-5	12	S1	13.6	Silty CLAY
E. 359,427	5-10	5	S2	26.6	Silty CLAY
EL. 215.0	10-28	3	S3	39.6	Clayey, SAND & SILT
	28-35	6			
	35-39	12			
	39-40	60			
	40-40.4	690			
	No Refusal				
PR-4570					
N. 1,812,581	0-6	4	S1	13.6	Silty CLAY
E. 359,624	6-10	5	S2	26.6	Silty CLAY
EL. 214.8	10-28	3	S3	33.4	SAND & SILT
	28-32	5			
	32-33	66			
	33-34	43			
	34-38	32			
	38-39	40			
	39-40	52			
	40-41	106			
	41-41.5	136			
	Refusal				

FILE NO. MC-A-2/45
PLATE III-46

ST. LAWRENCE RIVER

PROBING RESULTS - LONG SAULT CANAL, DIKE #3

Probing No. Coordinates and Surface Elevation	Depth in Feet	Blows per Foot	Samples No.	Samples Depth	Description of Samples
PH-4571					
N. 1,812,330	0-9	4	S1	13.6	Silty CLAY
E. 359,253	9-17	5	S2	26.6	Silty CLAY
EL. 215.0	17-39	7	S3	39.6	Clayey SAND & SILT
	39-40	12			
	40-42	38			
	42-44	25			
	44-45	44			
	45-46	64			
	46-47	147			
	47-48	280			
	No Refusal				
PH-4572					
N. 1,812,679	0-9	2	S1	13.6	Silty CLAY
E. 359,450	9-15	3	S2	26.6	Silty CLAY
EL. 214.8	15-20	5			
	20-30	7			
	30-30-4	670			
	No Refusal				

PH-

FILE NO MC-A-2/46
PLATE III-47

U. S. Engineer Office
St. Lawrence River District
Massena, New York

Sampler for Undisturbed Clays.

October 2, 1941

File No. C-26
Plate III-48

U. S. Engineer Office
St. Lawrence River District
Massena, New York

Sampler for Undisturbed Clays Unassembled.

October 2, 1941

File No. 0-27
Plate III-49

U. S. Engineer Office
St. Lawrence River District
Massena, New York

Undisturbed Sample Spoon Shoe
Flaps Retracted

Dimensions:
4-5/8" inside diameter
6" overall length

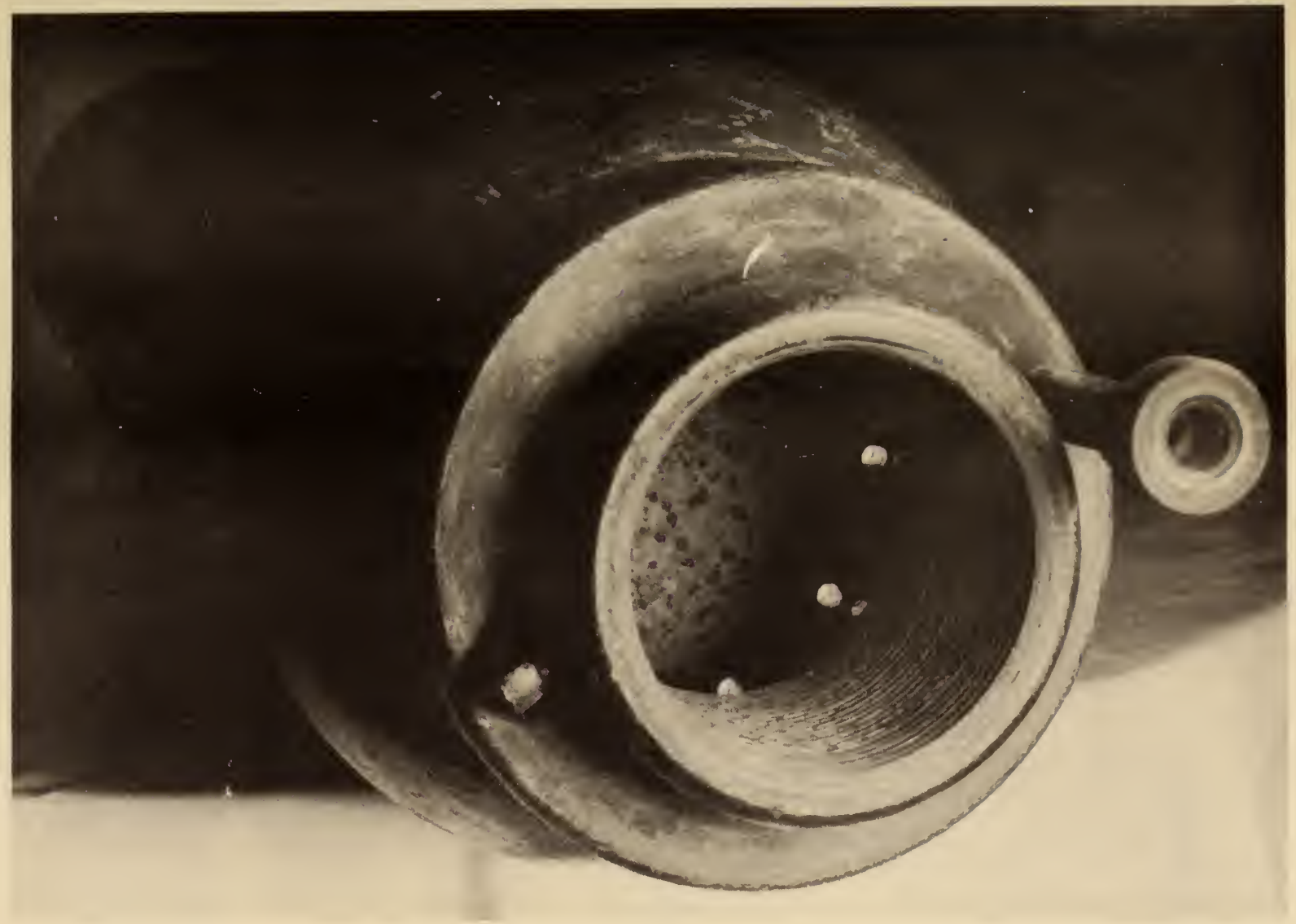
File No. 0-28
Plate III-50

U. S. Engineer Office
St. Lawrence River District
Massena, New York

Undisturbed Sample Spoon, Shoe Flaps in place ready for sampling.

October 2, 1941

File No. 0-29
Plate III-51

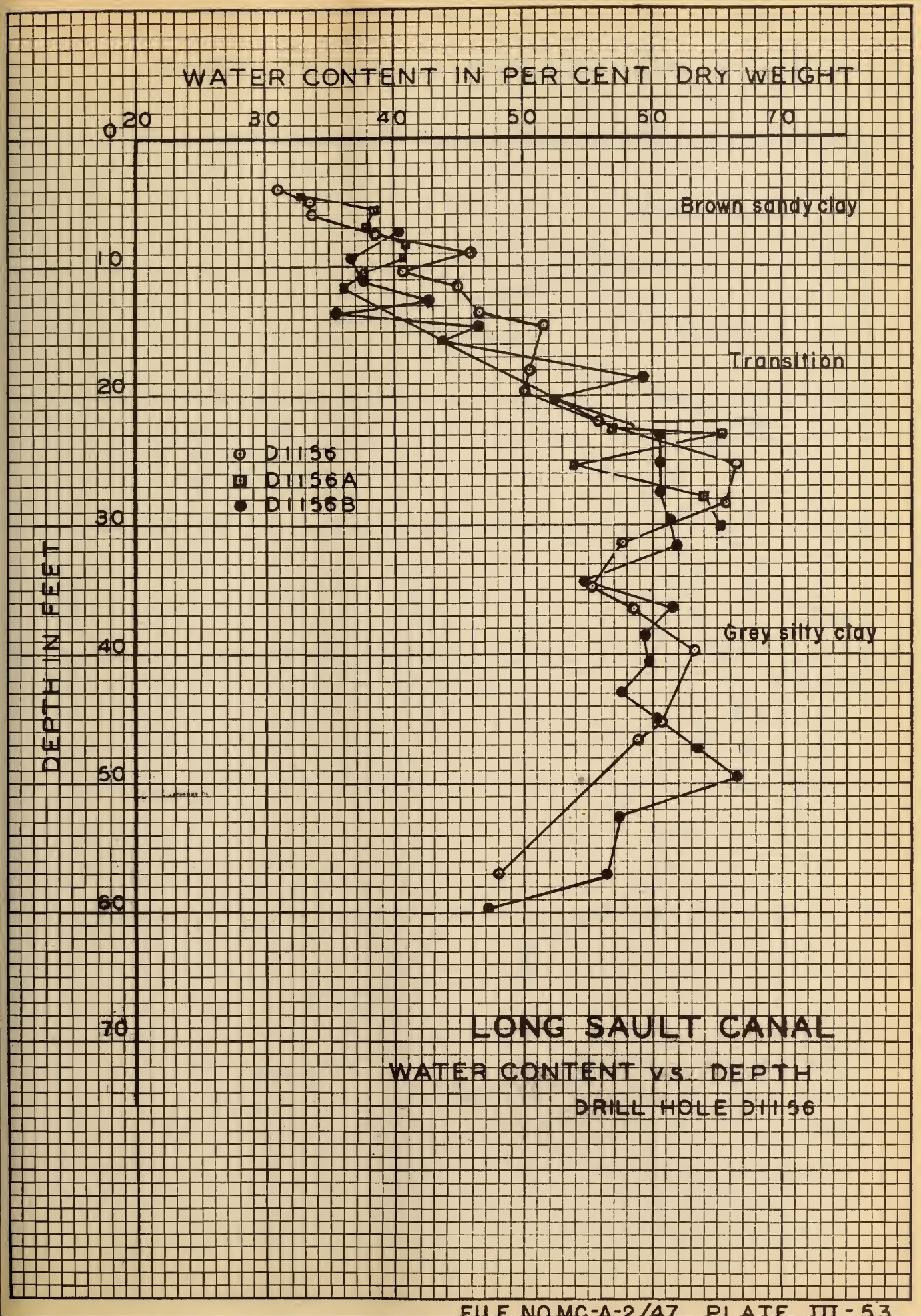


U. S. Engineer Office
St. Lawrence River District
Massena, New York

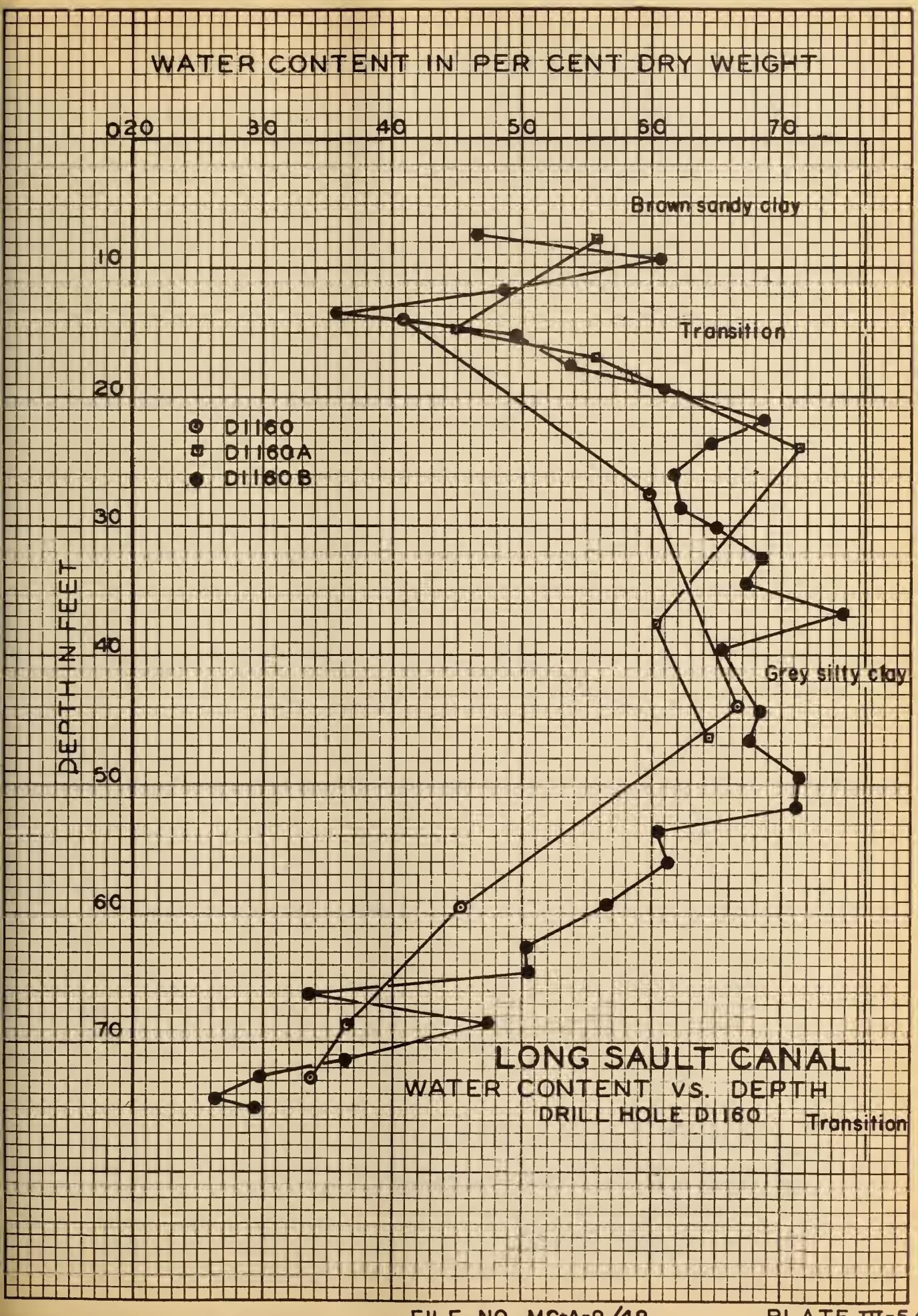
Sampler for Undisturbed Clays showing Baffle Diaphragm and Vacuum and Pressure Outlets.

October 2, 1941

File No. 0-30
Plate III-52

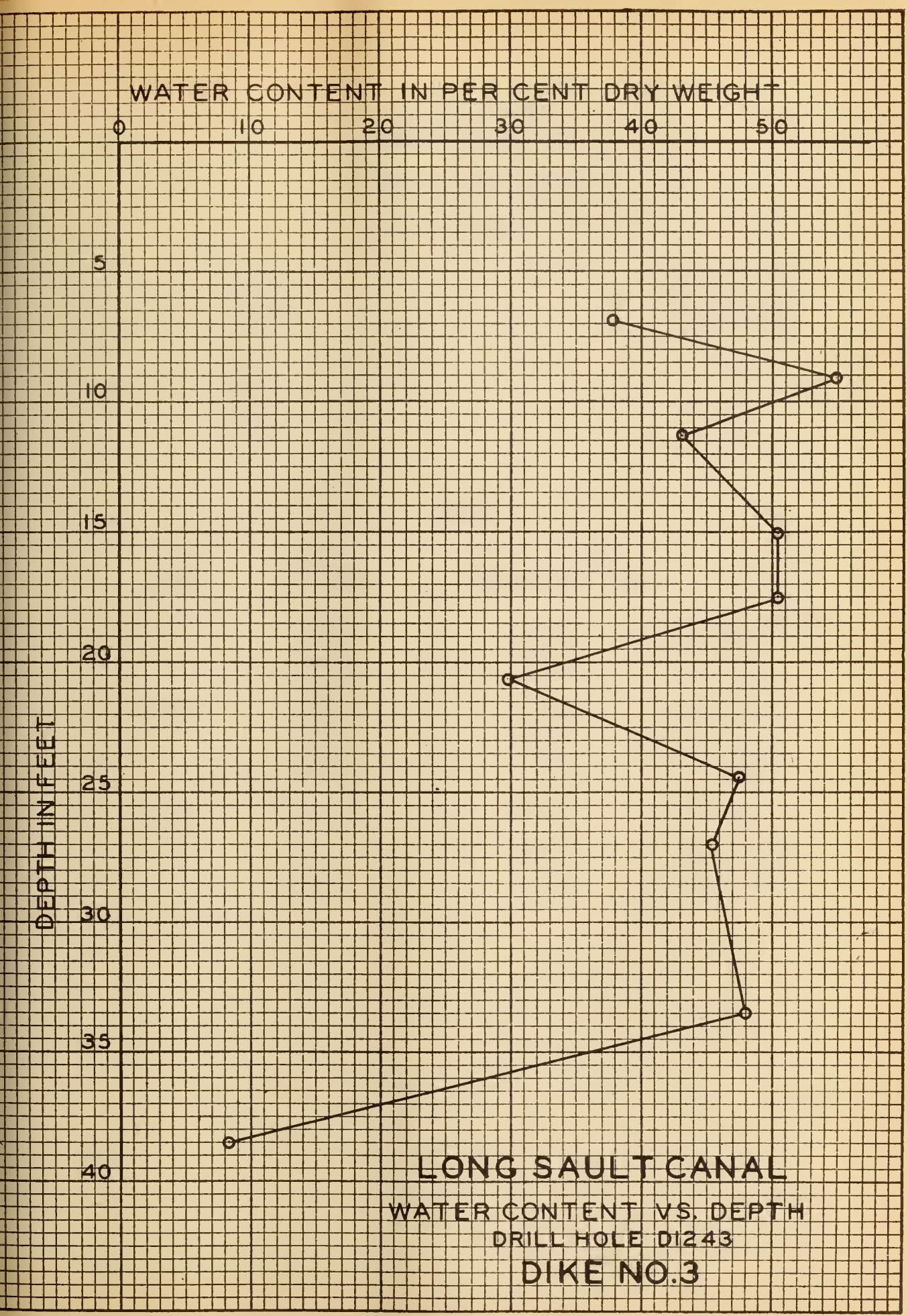


FILE NO MC-A-2/47 PLATE III - 53



FILE NO. MC-A-2/48

PLATE III-54



FILE NO. MC-A-2/49 PLATE III-55

LONG SAULT CANAL
SUMMARY OF TEST DATA

TYPICAL WATER CONTENTS

D-1759 (Glacial Till)

Depth (feet)	Water Content % Dry Weight
5.1	8.7
15.0	8.1
20.0	6.4
26.0	8.8
31.0	8.5

DENSITY

Drill Hole	Depth (feet)	Unit Wet Weight (lbs.per cu.ft.)	Material
D-1156	8.5	109.1	Brown Sandy Clay
	33.5	102.0	Gray Clay
	36.5	105.2	Gray Clay
D-1160	50.5	98.5	Gray Clay
	53.5	100.3	Gray Clay
	60.5	105.3	Gray Clay
	63.0	106.6	Gray Clay
D-1160	33.0	100.3	Gray Clay
D-1173	33.2	148.6	Glacial Till
	67.1	153.7	Glacial Till

LONG SAULT CANAL
SUMMARY OF TEST DATA

SPECIFIC GRAVITY

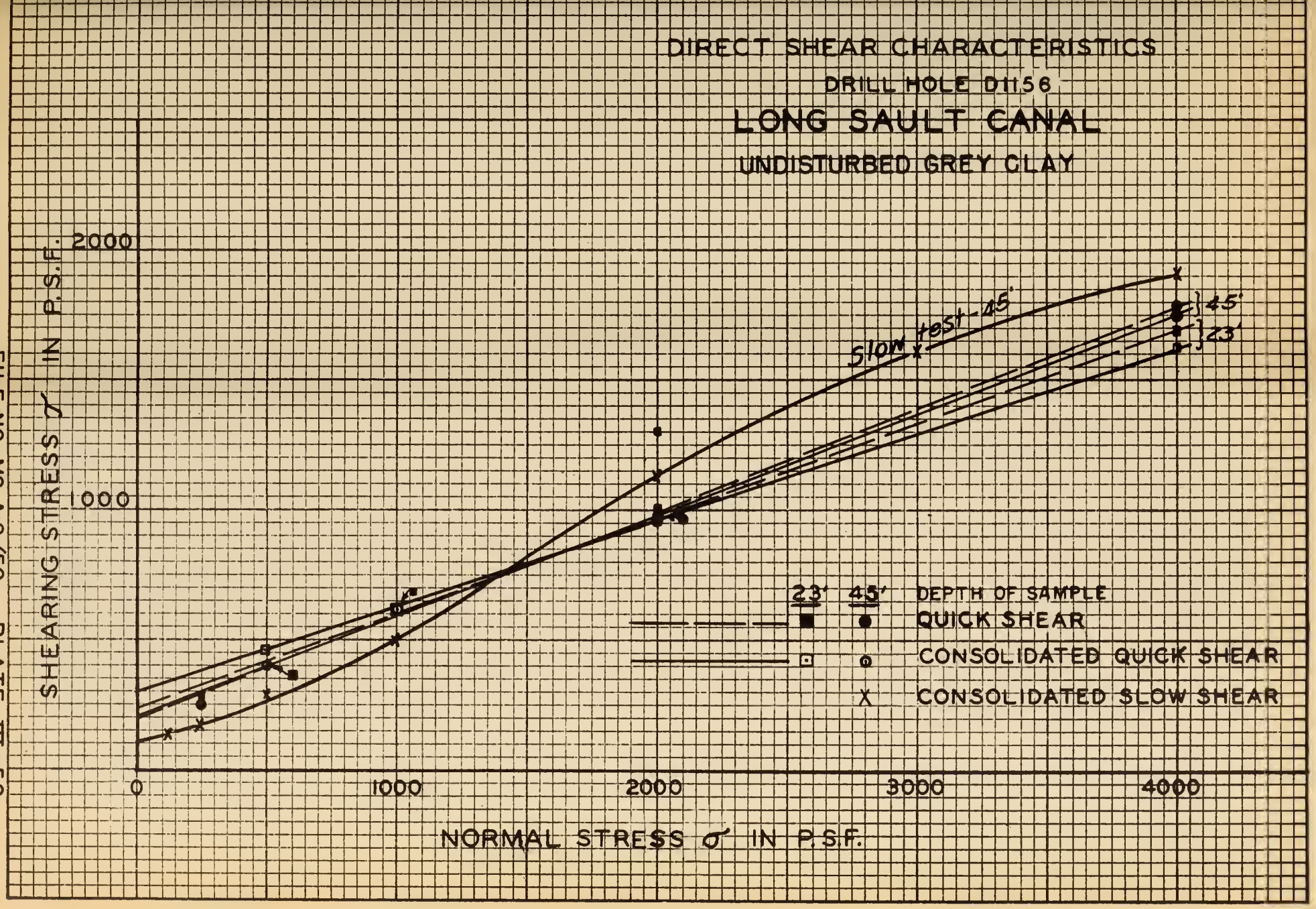
Drill Hole	Depth (feet)	Specific Gravity
	Clay	
D-1156	13.9	2.73
	22.1	2.76
	22.5	2.72
	33.6	2.71
	44.6	2.74
D-1156 B	7.5	2.68
	20.9	2.66
	20.9	2.75
	20.9	2.70
	21.9	2.73
	32.1	2.73
	40.9	2.71
	55.0	2.75
D-1160	51.7	2.72
	62.8	2.77
D-1160 A	32.9	2.79
	46.3	2.80
	46.3	2.82
D-1160 B	10.5	2.65
	20.0	2.75
	33.3	2.65
	73.9	2.63
D-1243	5.7	2.70
	18.2	2.73
	35.3	2.75
D-1279 A	7.1	2.70
	10.0	2.75
	11.6	2.74
T-1000p	14.3	2.77
	Till	
D-1149	61.3	2.76
D-1152	28.8	2.73
	34.5	2.72
D-1173	42.5	2.76

LONG SAULT CANAL
SUMMARY OF TEST DATA

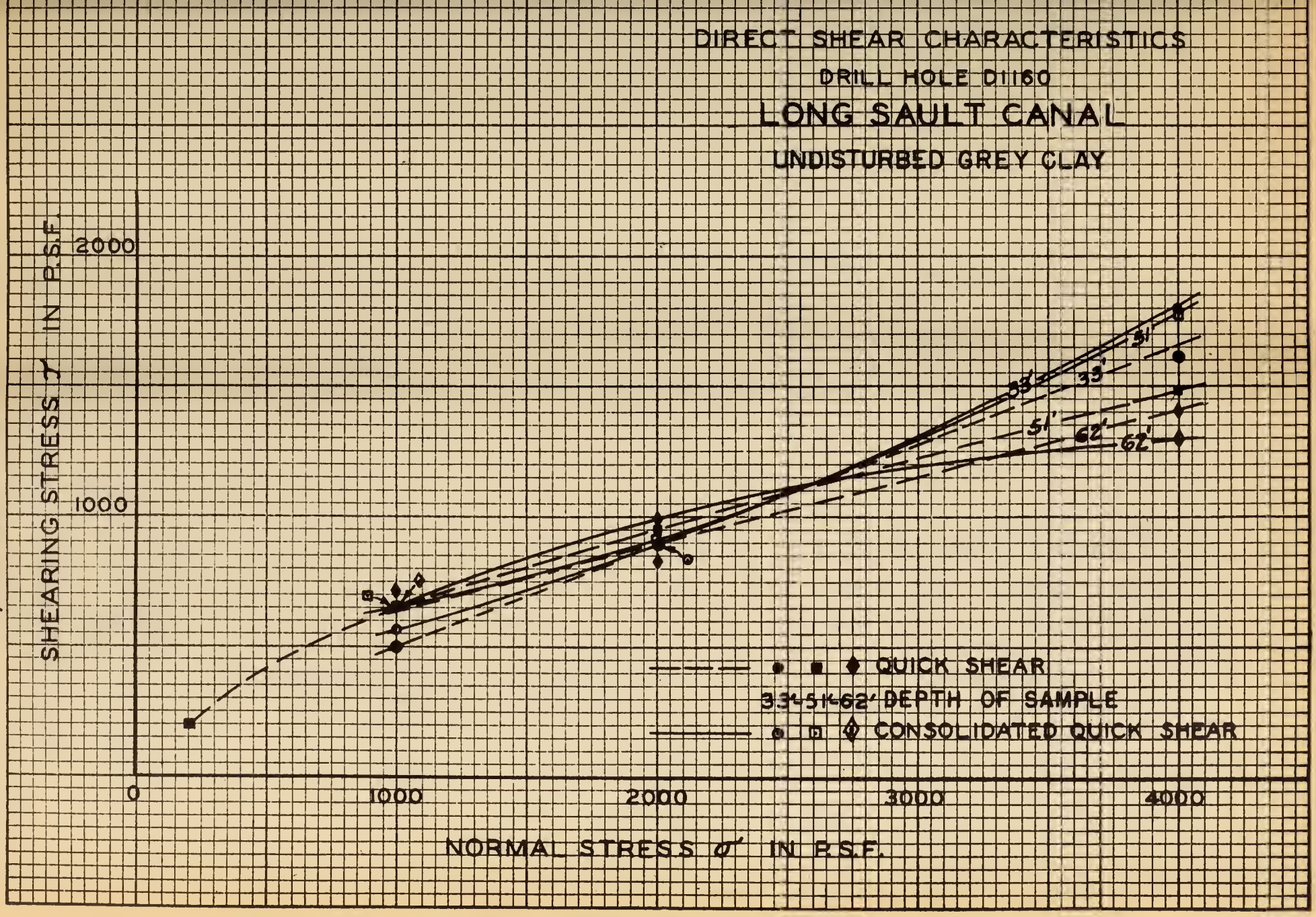
ATTERBERG LIMITS

Drill Hole	Depth (feet)	Liquid Limit	Plastic Limit
D-1156	13.9	54.2	
	20.0	44.3	
D-1156 B	7.5	49.1	23.7
	14.8	51.5	23.5
	20.9	43.2	31.3
	25.4	45.0	29.0
	30.5	47.0	31.1
	36.4	43.8	29.8
	40.8	42.0	32.0
	47.5	49.4	34.0
	55.0	56.1	33.5
D-1160	51.8	38.3	
	63.0	45.8	
D-1160 A	32.9	44.1	
D-1160 B	10.5	59.0	39.1
	24.8	54.7	30.9
	40.5	54.0	31.0
	52.8	53.7	31.4
	66.4	44.4	22.8
D-1243	5.7	37.3	23.8
	18.2	48.7	26.9
	35.3	26.1	16.1
D-1279	7.1	69.6	31.0
D-1279 A	10.0	61.5	33.0
D-1279 B	13.9	42.5	25.1
T-1000p	14.3	40.2	

Limits stated as water contents in percent of dry weight.

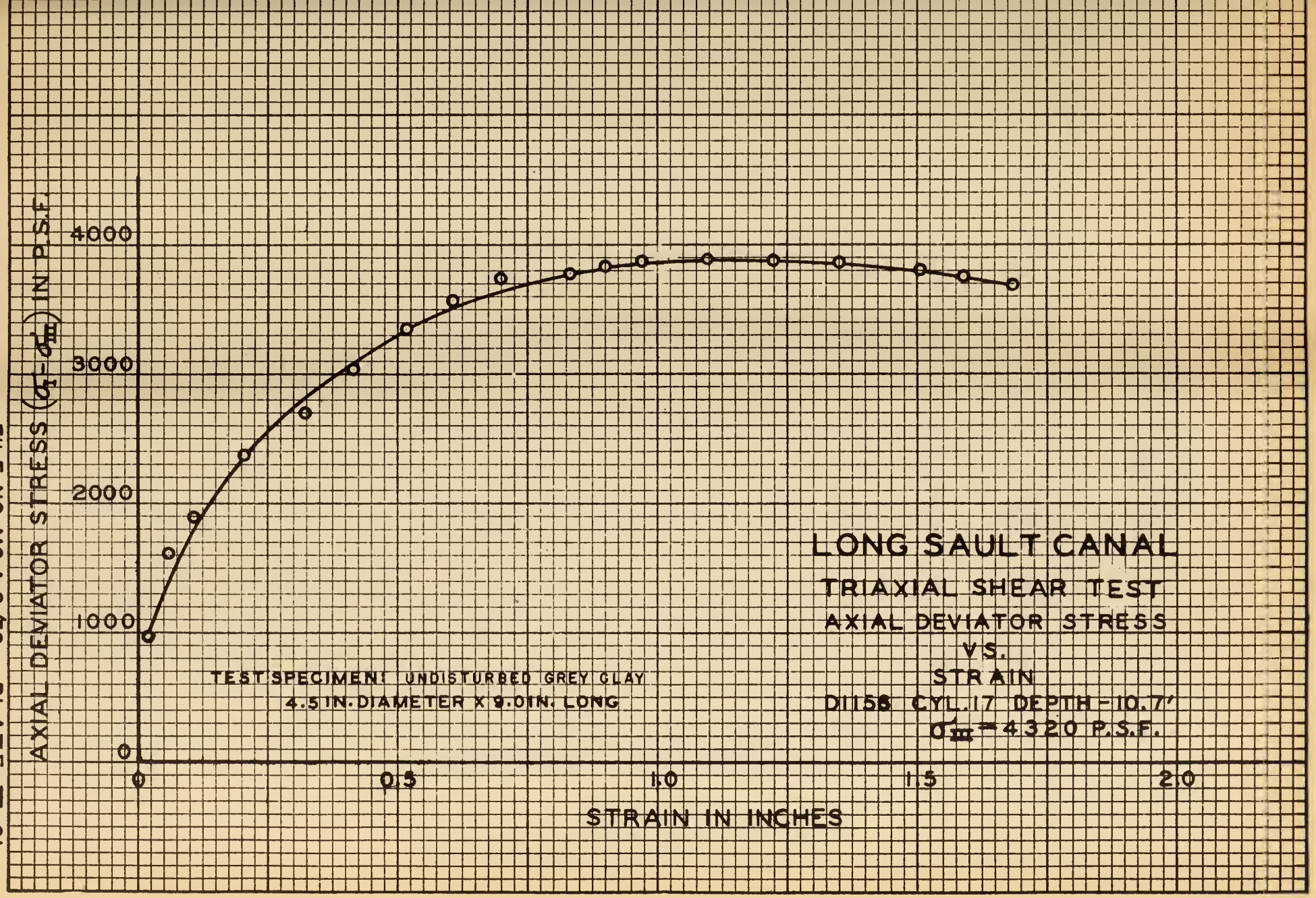


FILE NO. MC-A-2/50 PLATE III-59



FILE NO. MC-A-2/51

PLATE III-60



FILE NO. MC-A-2/52 PLATE III-61

TEST RESULTS
LONG SAULT CANAL
TRIAXIAL SHEAR TESTS

No.	Ithaca Test No.	Cyl. No.	Depth (ft.)	σ_3 (tsf)	Max. σ_1 (tsf)	Strain at Max. (%)	Time to Reach Max. (Minutes)	Original w (%)	Final w (%)
				Hole D-1156-B - Consolidated Quick Tests					
1	30	6	11.5	0.29	1.58	15.0	17	37.0	
2	31	6	11.5	0.64	2.27	9.2	11	37.0	
3	28	8	16.4	0.40	1.64	13.2	12.5	52.0	43.8
4	35	9	17.4	0.97	1.99	8.5	5	47.4	42.5
5	34	10	19.0	0.47	1.35	10.8	6	50.0	53.5
6	32	14	24.0	0.59	1.52	5.5	4	58.5	62.9
7	33	14	24.0	1.34	2.70	5.5	4	58.5	53.0
8	25	17	27.7	0.68	1.77	6 1	10.0	59.0	54.2
9	36	18	28.6	0.71	1.62	11.5	6	62.5	61.8
10	37	18	28.6	1.60	3.15	4.6	3	62.5	53.8
11	29	21	33.0	0.81	2.02	7.6	8.0	58.8	47.8
12	38	24	37.2	0.91	1.89	7.6	4	56.3	56.4
13	39	24	37.2	2.06	3.64	7.1	4	56.3	48.6
14	27	26	39.4	0.97	2.25	5.0	4.5	58.8	52.8
15	41	29	43.2	1.07	2.23	7.3	3	60.6	55.7
16	40	29	43.2	2.41	4.20	5.2	3	60.6	51.1
17	42	32	48.3	1.19	2.50	4.4	3	63.9	63.4
18	45	32	48.3	2.69	4.88	3.9	3	63.9	52.7
19	26	34	51.2	1.26	2.93	2.5	3.0	64.3	59.5
20	46	36	55.9	1.38	2.66	4.3	3	58.8	57.1
21	47	36	55.9	3.12	5.26	4.5	3	58.8	48.9

TEST RESULTS
LONG SAULT CANAL
TRIAXIAL SHEAR TESTS

No.	Ithaca Test No.	Cyl. No.	Depth (ft.)	σ_3 (tsf)	Max. σ_1 (tsf)	Strain at Max. (%)	Time to Reach Max. (Minutes)	Original w (%)	Final w (%)
				Hole D-1160-B - Consolidated-Quick Tests					
1	49	6	12.2	0.25	1.12	7.1	3.5	39.4	35.3
2	48	6	12.2	0.63	1.44	13.2	7.0	35.8	34.2
3	51	12	20.8	0.43	1.04	6.2	3.5	69.1	67.8
4	50	12	20.8	1.08	2.21	2.5	1.5	68.9	63.7
5	53	16	26.5	1.37	2.58	4.6	2.5	61.0	53.8
6	52	18	30.4	0.63	1.31	6.0	3.5	63.9	63.3
7	54	21	34.9	0.72	1.69	1.6	1.0	65.7	62.7
8	55	21	34.9	1.82	3.15	4.1	2.5	66.7	65.2
9	56	26	42.1	0.88	1.70	4.1	2.5	65.7	66.9
10	57	26	42.1	2.19	3.67	4.4	2.5	65.7	52.6
11	59	32	49.8	1.03	2.10	3.3	2.0	67.3	65.4
12	58	32	49.8	2.59	4.34	3.5	2.0	67.3	54.3
13	60	36	54.9	1.14	2.49	3.6	2.0	53.9	56.8
14	64	36	54.9	2.85	4.49	3.3	2.0	53.9	48.3
15	61	40	61.4	1.27	2.38	3.3	2.0	56.6	48.4
16	65	40	61.4	3.18	5.09	3.2	2.5	56.6	46.8
17	67	45	70.1	1.45	2.48	3.4	2.0	42.8	40.3
18	66	45	70.1	3.60	5.43	2.5	1.5	42.8	38.3
				Hole D-1156 - Quick Tests					
1	7	5	8.2	1.08	2.53	14.0		46.0	
2	6	6	9.5	0.43	1.71	11.2		43.9	
3	8	7	10.7	2.16	4.11	12.7		43.1	
4	9	8	12.8	4.32	5.84	13.6		43.5	
5	5	12	21.3		0.40	4.0		55.3	
6	1	14	33.6		0.47	10.9		54.5	
7	3	15	34.7	2.16	2.90	13.8		56.1	
8	2	16	35.9	1.08	1.79	13.2		58.0	
9	4	19	50.6	4.32	4.94	9.0		60.0	
10	44	1	5.2		0.40	17.5	10.0	39.2	
11	43	2	6.2		0.53	2.3	1.0	35.8	
12	135	12	21.9		0.75	8.5	4.5	56.4	55.4
13	136	12	21.9	0.95	1.69	14.1	8.0	56.4	55.7
14	153	13	23.3		0.39	6.7	3.5	57.7	57.5
15	137	20	32.1		0.40	7.6	4.0	57.3	57.0
16	138	20	32.1	1.16	1.79	19.5	11.0	59.1	58.8
16a	184	22	35.1	0.43	1.10	14.1	7.5	60.8	60.8
17	152	25	38.6		0.34	8.6	4.5	64.5	57.9
18	139	27	40.9	1.36	2.03	9.3	5.0	60.6	60.0
19	140	33	50.2	1.56	2.27	9.3	5.0	66.1	65.9

TEST RESULTS
LONG SAULT CANAL
TRIAXIAL SHEAR TESTS

No.	Ithaca Test No.	Cyl. No.	Depth (feet)	σ_3 (tsf)	Max. σ_1 (tsf)	Strain at Max. (%)	Time to Reach Max. (Minutes)	Original w (%)	Final w (%)
			Hole D-1156-B - Slow Tests; No Drainage (Rate of Loading = 0.003 inches/min.)						
20	181[1]	15	25.4	0.43	0.85	15.0	270.0	61.6	61.5
21	179[2]	16	26.2	0.00	0.63	15.0	190.0	63.3	62.9
22	180[2]	16	26.2	0.43	1.02+	10.0±	180.0±	57.5	57.2
23	182	19	30.5	1.08	1.74	16.0	290.0	55.2	55.2
24	183	22	35.1	2.16	2.72	16.0	300.0	63.2	63.2
			Hole D-1160 - Quick Tests						
1	16	9	53.8	0.43	1.02	9.3		58.4	
2	15	10	55.3	1.08	1.96	7.5		36.2	
3	14	11	56.7	4.32	4.99	7.7		64.7	
4	17	14	64.8	2.16	2.78	14.8		48.7	
5	23	16	69.4	Unconf.	0.37	9.7		42.0	
			Hole D-1160-A - Quick Tests						
6	18	10	19.4	0.43	0.90	15.9		53.3	
7	24	11	20.4	Unconf.	0.44	10.1		60.9	
8	19	12	22.8	1.08	1.67	9.4		64.5	
9	20	14	25.3	2.16	2.80	12.8		58.7	
10	21	15	30.5	4.32	4.67	12.0		79.0	
			Hole D-1160-B - Quick Tests						
10a	63	3	8.1		0.49	3.9	2.0	58.4	58.1
11	159	7	14.1	0.28	0.76	16.1	9.5	43.5	42.8
12	160	19	31.2	0.63	1.22	11.0	6.0	65.8	64.7
13	161	33	50.7	1.02	1.59	14.2	7.5	68.3	67.0
14	162	46	72.0	1.44	2.09	13.7	8.0	39.2	38.8
			Hole D-1243 - Consolidated-Quick Tests						
1	102	1	5.7	0.43	1.31	15.9	8.5	32.1	36.9
3	99	2	7.2	1.08	2.52	7.6	4.0	29.3	23.1
5	100	3	8.0	2.16	3.80	1.7	1.0	52.4	42.1
8	105	6	12.3	0.43	1.24	5.2	3.0	50.5	48.0
9	104	7	14.0	1.08	2.27	9.5	5.0	50.3	44.3
10	103	7	14.0	2.16	3.69	9.5	5.5	50.3	41.3
13	106	13	25.9	0.43	1.17	11.7	7.0	45.8	42.3
15	107	15	32.3	1.08	2.12	6.7	4.0	43.3	39.1
16	108	15	32.3	2.16	3.53	6.3	3.5	43.3	35.7

[1] Rate of loading = 0.004 inches/minute

[2] Test interrupted, maximum values extrapolated

TEST RESULTS
LONG SAULT CANAL
TRIAXIAL SHEAR TESTS

No.	Ithaca Test No.	Cyl. No.	Depth (ft.)	σ_3 (tsf)	Max. σ_1 (tsf)	Strain at Max. (%)	Time to Reach Max. (Minutes)	Original w (%)	Final w (%)
				Hole D-1243 - Quick Tests					
2	90	2	7.2		0.35	19.9	11.5	37.4	46.7
4	91	3	8.0		0.51	4.3	2.5	51.2	49.2
6	171	5	11.6	0.26	0.66	14.0	7.5	52.5	51.9
7	98	6	12.3		0.62	13.1	8.0	50.5	52.4
11	174	10	18.0	1.44	2.05	15.7	9.0	50.0	49.0
12	101	13	25.9		0.39	9.6	5.0	45.8	45.4
14	172	14	27.7	0.63	1.17	12.6	7.0	45.0	44.5
				Hole D-1279 - Quick Tests					
1	167	1	5.2	0.54	2.02	15.5	8.5	44.6	44.6
2	168	3	7.1	1.08	2.32	13.4	7.5	56.4	55.9
				Hole D-1279-A - Quick Tests					
3	68	1	5.8		0.76	2.6	1.5	48.3	48.3
5	78	3	8.0		0.65	4.7	2.5	56.7	56.7
7	77	4	10.0		0.89	10.4	6.0	50.0	50.0
				Hole D-1279-A - Consolidated Quick Tests					
4	82	2	7.2	2.16	3.88	4.5	2.5	47.6	45.4
6	76	3	8.0	2.16	4.10	4.5	3.0	56.6	54.9
8	74	5	11.5	0.54	1.23	10.8	6.5	53.1	52.3
9	73	5	11.5	1.08	1.94	9.9	5.5	51.6	47.6
				Hole D-1279-B - Consolidated Quick Tests					
10	72	1	5.6	0.54	2.12	14.7	8.0	44.6	44.9
11	71	1	5.6	2.16	4.25	8.0	5.5	45.5	44.2
12	80	2	7.1	1.08	2.20	12.8	7.0	53.9	50.1
13	75	2	7.1	2.68	4.89	4.8	3.0	59.1	52.9
14	79	3	7.9	0.54	1.90	5.4	3.0	51.5	50.3
15	81	5	13.9	2.16	3.55	3.2	2.0	43.8	40.7

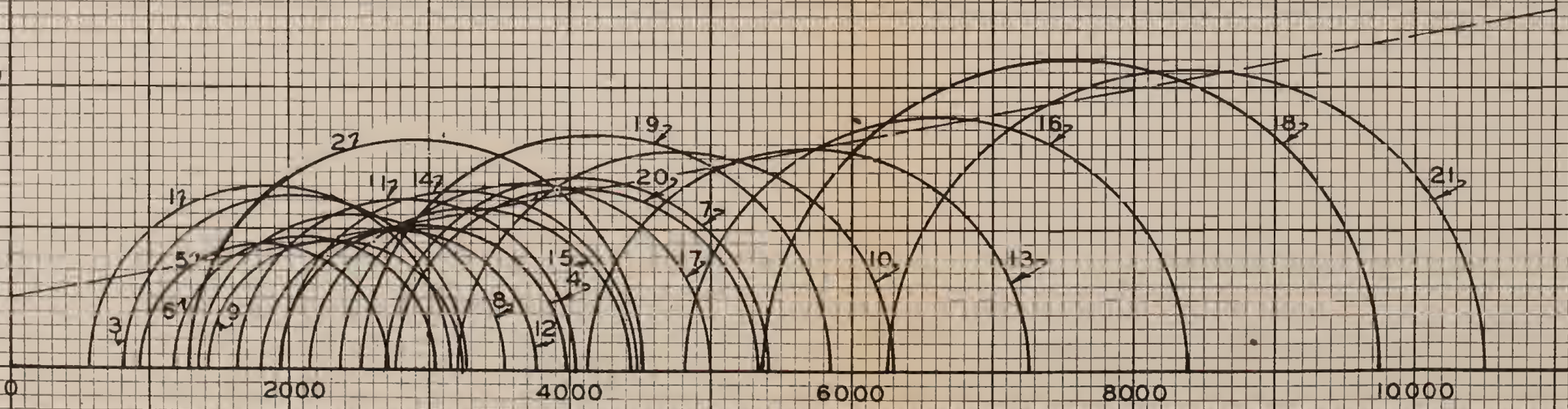
TRIAXIAL SHEAR TESTS
CONSOLIDATED QUICK SHEAR
UNDISTURBED CLAY SAMPLES

GREY CLAY

DRILL HOLE D1156B

LONG SAULT CANAL

NO.	HOLE	SAMPLE NO.	DEPTH	SIZE
1	D1156B	CYL. 6	11.5'	2.8 IN. DIAM X 5.6 IN. LONG
2	"	" 6	11.5'	2.8 " " X 5.6 " "
3	"	" 8	16.4'	4.5 " " X 9.0 " "
4	"	" 9	7.4'	2.8 " " X 5.6 " "
5	"	" 10	19.0'	2.8 " " X 5.6 " "
6	"	" 14	24.0'	2.8 " " X 5.6 " "
7	"	" 14	24.0'	2.8 " " X 5.6 " "
8	"	" 17	27.7'	4.5 " " X 9.0 " "
9	"	" 18	28.6'	2.8 " " X 5.6 " "
10	"	" 18	28.8'	2.8 " " X 5.6 " "
11	"	" 21	33.0'	4.5 " " X 9.0 " "
12	"	" 24	37.2'	2.8 " " X 5.6 " "
13	"	" 24	37.2'	2.8 " " X 5.6 " "
14	"	" 26	39.4'	4.5 " " X 9.0 " "
15	"	" 29	43.2'	2.8 " " X 5.6 " "
16	"	" 29	43.2'	2.8 " " X 5.6 " "
17	"	" 32	48.3'	2.8 " " X 5.6 " "
18	"	" 32	48.3'	2.8 " " X 5.6 " "
19	"	" 34	51.2'	4.5 " " X 9.0 " "
20	"	" 36	55.9'	2.8 " " X 5.6 " "
21	"	" 36	55.9'	2.8 " " X 5.6 " "



FILE NO MC-A-2/53

PLATE III-66

TRIAXIAL SHEAR TESTS
CONSOLIDATED QUICK SHEAR
UNDISTURBED CLAY SAMPLES

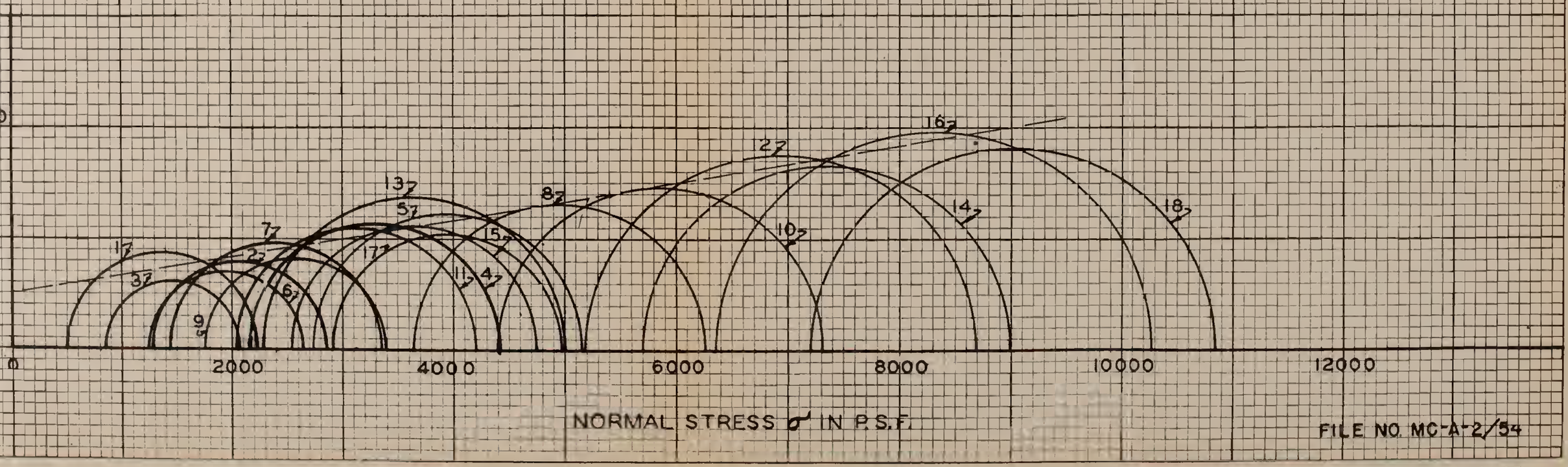
GREY CLAY

2.8 IN. DIAM. X 5.6 IN. LONG

DRILL HOLE D1160B

LONG SAULT CANAL

NO.	HOLE	SAMPLE NO.	DEPTH
1	D1160B	CYL. 6	12.2'
2	"	" 6	12.2'
3	"	" 2	20.8'
4	"	" 12	20.8'
5	"	" 16	26.5'
6	"	" 18	30.4'
7	"	" 21	34.9'
8	"	" 21	34.9'
9	"	" 26	42.1'
10	"	" 26	42.1'
11	"	" 32	49.8'
12	"	" 32	49.8'
13	"	" 36	54.9'
14	"	" 36	54.9'
15	"	" 40	61.4'
16	"	" 40	61.4'
17	"	" 45	70.1'
18	"	" 45	70.1'



FILE NO. MC-A-2/54

TRIAXIAL SHEAR TESTS
QUICK SHEAR
UNDISTURBED CLAY SAMPLES
DRILL HOLES D1156 & D1156B
LONG SAULT CANAL

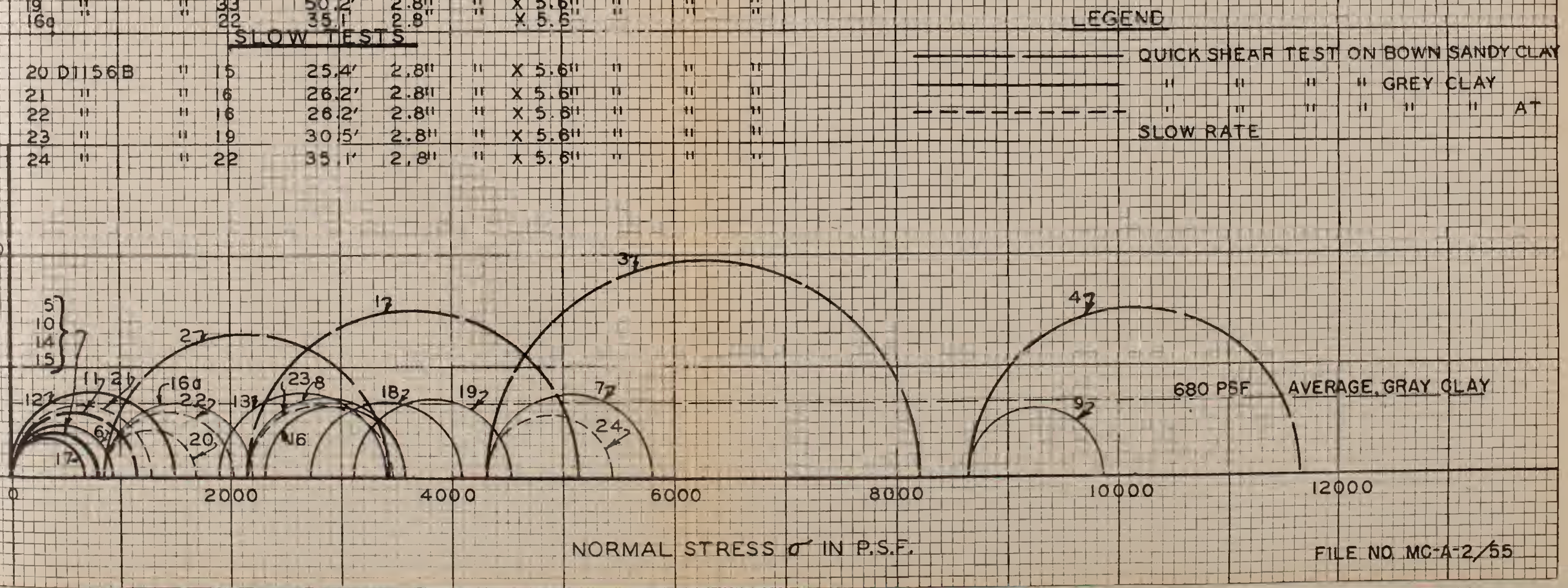
NO.	HOLE	SAMPLE NO.	DEPTH	SIZE	MATERIAL
1	D1156	CYL 5	8.2'	4.5 IN. DIAM. X 9.0 IN. LONG	BROWN SANDY CLAY
2	"	" 6	9.7'	4.5" " X 9.0" "	" " "
3	"	" 7	10.8'	4.5" " X 9.0" "	" " "
4	"	" 8	12.8'	4.5" " X 9.0" "	" " "
5	"	" 12	20.8'	4.5" " X 9.0" "	GREY CLAY
6	"	" 14	33.5	4.5" " X 9.0" "	" "
7	"	" 15	34.5'	4.5" " X 9.0" "	" "
8	"	" 16	36.0'	4.5" " X 9.0" "	" "
9	"	" 19	51.0'	4.5" " X 9.0" "	" "
10	D1156B	"	5.2'	2.8" " X 5.6" "	BROWN SANDY CLAY
11	"	" 2	6.2'	2.8" " X 5.6" "	" " "
12	"	" 12	21.9'	2.8" " X 5.6" "	GREY CLAY
13	"	" 12	21.9'	2.8" " X 5.6" "	" "
14	"	" 13	23.3'	2.8" " X 5.6" "	" "
15	"	" 20	32.1'	2.8" " X 5.6" "	" "
16	"	" 20	32.1'	2.8" " X 5.6" "	" "
17	"	" 25	38.6'	2.8" " X 5.6" "	" "
18	"	" 27	40.9'	2.8" " X 5.6" "	" "
19	"	" 33	50.2'	2.8" " X 5.6" "	" "
16a	"	" 22	35.1	2.8" " X 5.5	" "

SLOW TESTS

20	D1156B	" 15	25.4'	2.8" " X 5.6" "	"	"
21	"	" 16	26.2'	2.8" " X 5.6" "	"	"
22	"	" 16	26.2'	2.8" " X 5.6" "	"	"
23	"	" 19	30.5'	2.8" " X 5.6" "	"	"
24	"	" 22	35.1'	2.8" " X 5.6" "	"	"

LEGEND

QUICK SHEAR TEST ON BOWN SANDY CLAY
" " " " GREY CLAY
" " " " " " AT SLOW RATE

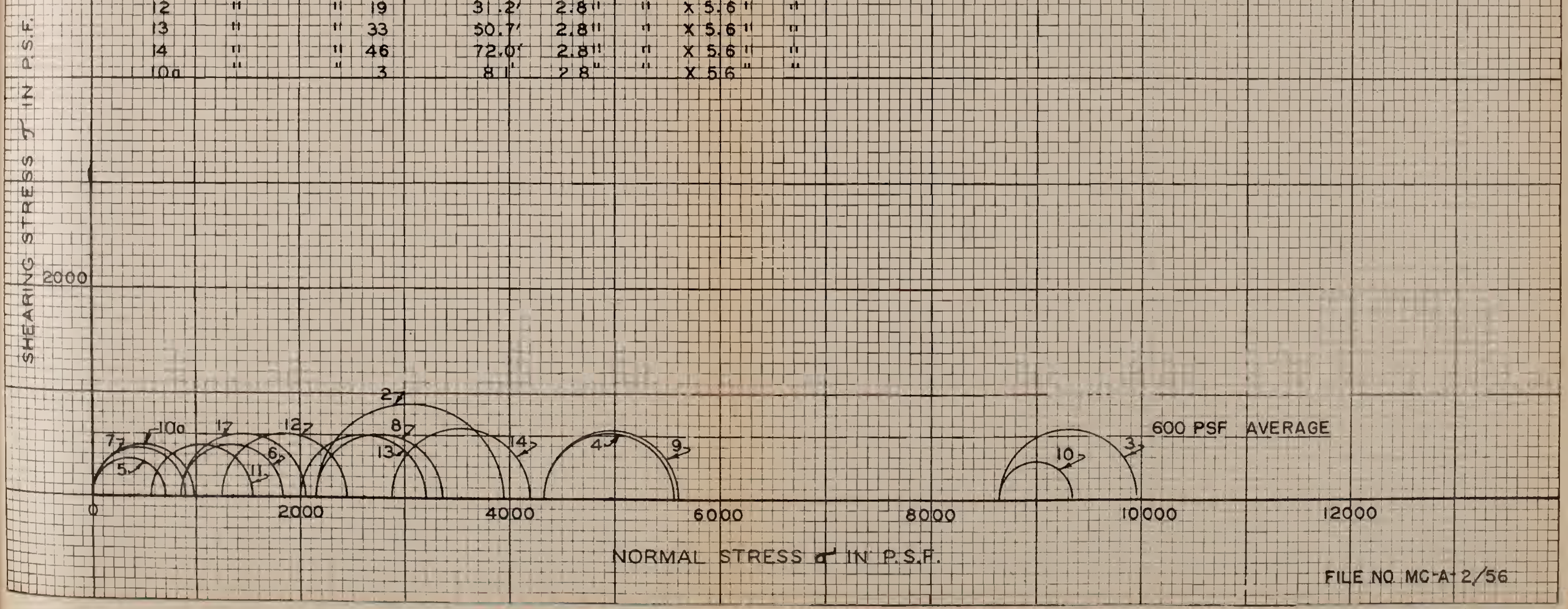


FILE NO. MC-A-2/55

PLATE III-68

TRIAXIAL SHEAR TESTS
QUICK SHEAR
UNDISTURBED CLAY SAMPLES
GREY CLAY
LONG SAULT CANAL
DRILL HOLES D1160, D1160A & D1160B

NO.	HOLE	SAMPLE NO.	DEPTH	SIZE
1	D1160	CYL. 9	53.8'	4.5IN. DIAM. X 9.0IN. LONG
2	"	" 10	55.3'	4.5 " " X 9.0 " "
3	"	" 11	56.7'	4.5 " " X 9.0 " "
4	"	" 14	64.7'	4.5 " " X 9.0 " "
5	"	" 16	69.4'	4.5 " " X 9.0 " "
6	D1160A	" 10	19.4'	4.5 " " X 9.0 " "
7	"	" 11	20.9'	4.5 " " X 9.0 " "
8	"	" 12	22.8'	4.5 " " X 9.0 " "
9	"	" 14	25.3'	4.5 " " X 9.0 " "
10	"	" 15	31.5'	4.5 " " X 9.0 " "
11	D1160B	" 7	14.1'	2.8 " " X 5.6 " "
12	"	" 19	31.2'	2.8 " " X 5.6 " "
13	"	" 33	50.7'	2.8 " " X 5.6 " "
14	"	" 46	72.0'	2.8 " " X 5.6 " "
10a	"	" 3	81'	2.8 " " X 5.6 " "



FILE NO. MC-A 2/56

TRIAXIAL SHEAR TESTS
UNDISTURBED CLAY SAMPLES

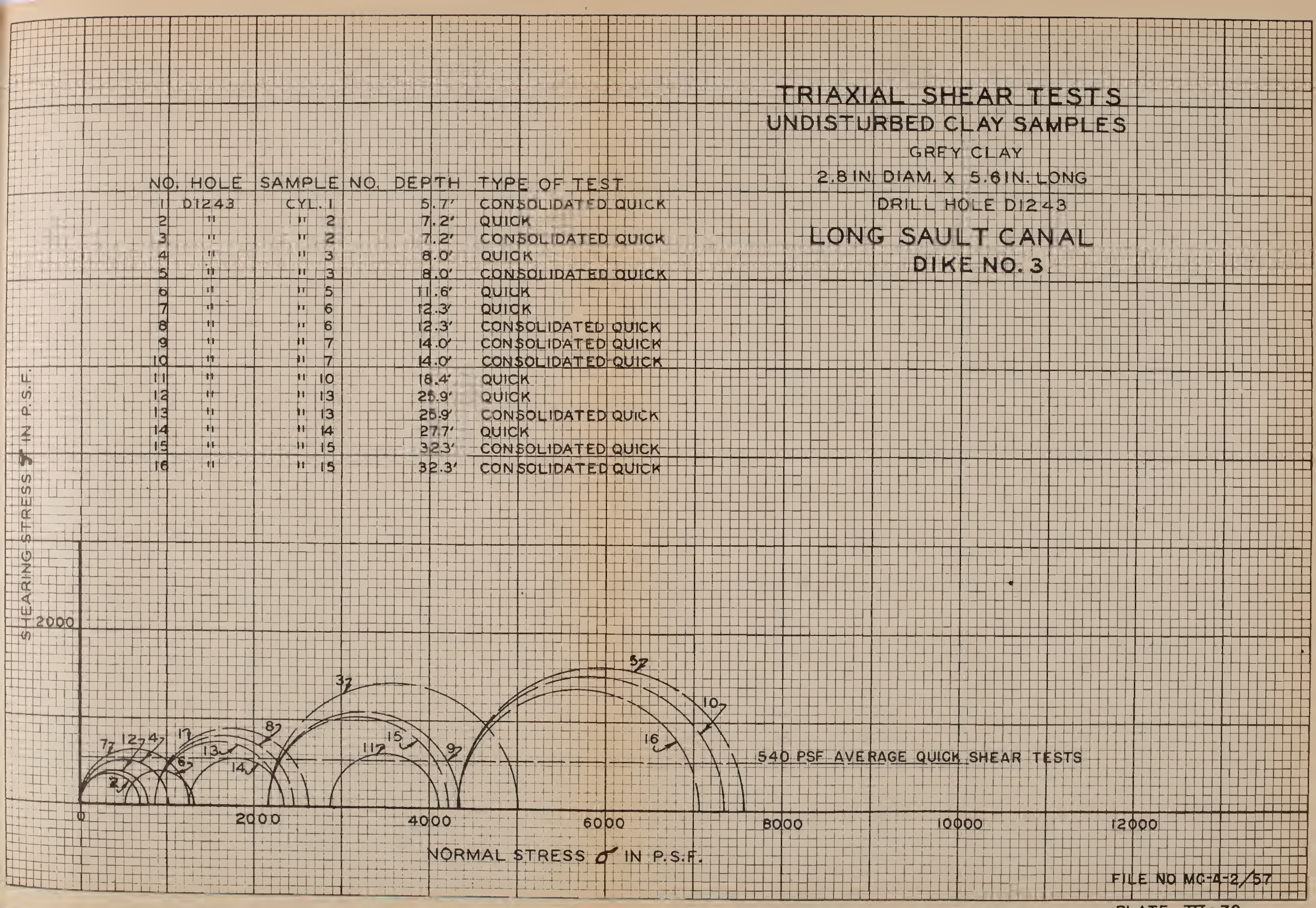
GREY CLAY

2.8 IN. DIAM. X 5.6 IN. LONG

DRILL HOLE D1243

LONG SAULT CANAL
DIKE NO. 3

NO.	HOLE	SAMPLE NO.	DEPTH	TYPE OF TEST
1	D1243	CYL. 1	5.7'	CONSOLIDATED QUICK
2	"	" 2	7.2'	QUICK
3	"	" 2	7.2'	CONSOLIDATED QUICK
4	"	" 3	8.0'	QUICK
5	"	" 3	8.0'	CONSOLIDATED QUICK
6	"	" 5	11.6'	QUICK
7	"	" 6	12.3'	QUICK
8	"	" 6	12.3'	CONSOLIDATED QUICK
9	"	" 7	14.0'	CONSOLIDATED QUICK
10	"	" 7	14.0'	CONSOLIDATED QUICK
11	"	" 10	18.4'	QUICK
12	"	" 13	25.9'	QUICK
13	"	" 13	25.9'	CONSOLIDATED QUICK
14	"	" 14	27.7'	QUICK
15	"	" 15	32.3'	CONSOLIDATED QUICK
16	"	" 15	32.3'	CONSOLIDATED QUICK



FILE NO MC-4-2/57

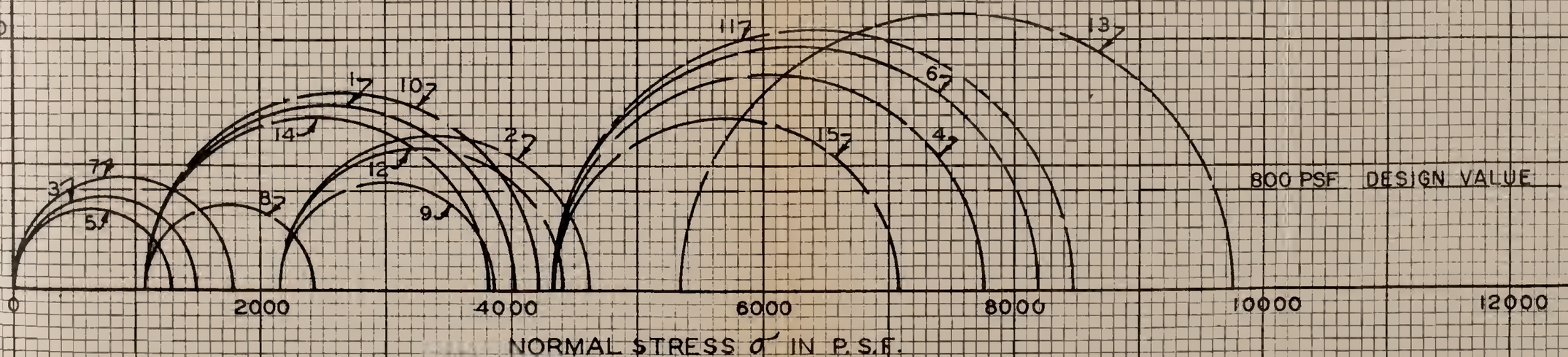
PLATE III-70

TRIAXIAL SHEAR TESTS
UNDISTURBED CLAY SAMPLES
GREY CLAY

2.8 IN. DIAM. X 5.6 IN. LONG

LONG SAULT CANAL
DIKE NO. 3
DRILL HOLES D1279, D1279A & D1279B

NO.	HOLE	SAMPLE NO.	DEPTH	TYPE OF TEST
1	D1279	CYL. 1	5.3'	QUICK
2	"	" 3	7.1'	"
3	D1279A	" 1	5.8'	"
4	"	" 2	7.3'	CONSOLIDATED QUICK
5	"	" 3	8.0'	QUICK
6	"	" 3	8.0'	CONSOLIDATED QUICK
7	"	" 4	10.0'	QUICK
8	"	" 5	11.5'	CONSOLIDATED QUICK
9	"	" 5	11.5'	" "
10	D1279B	" 1	5.6	" "
11	"	" 1	5.6'	" "
12	"	" 2	7.1'	" "
13	"	" 2	7.1'	" "
14	"	" 3	7.9'	" "
15	"	" 5	13.9'	" "

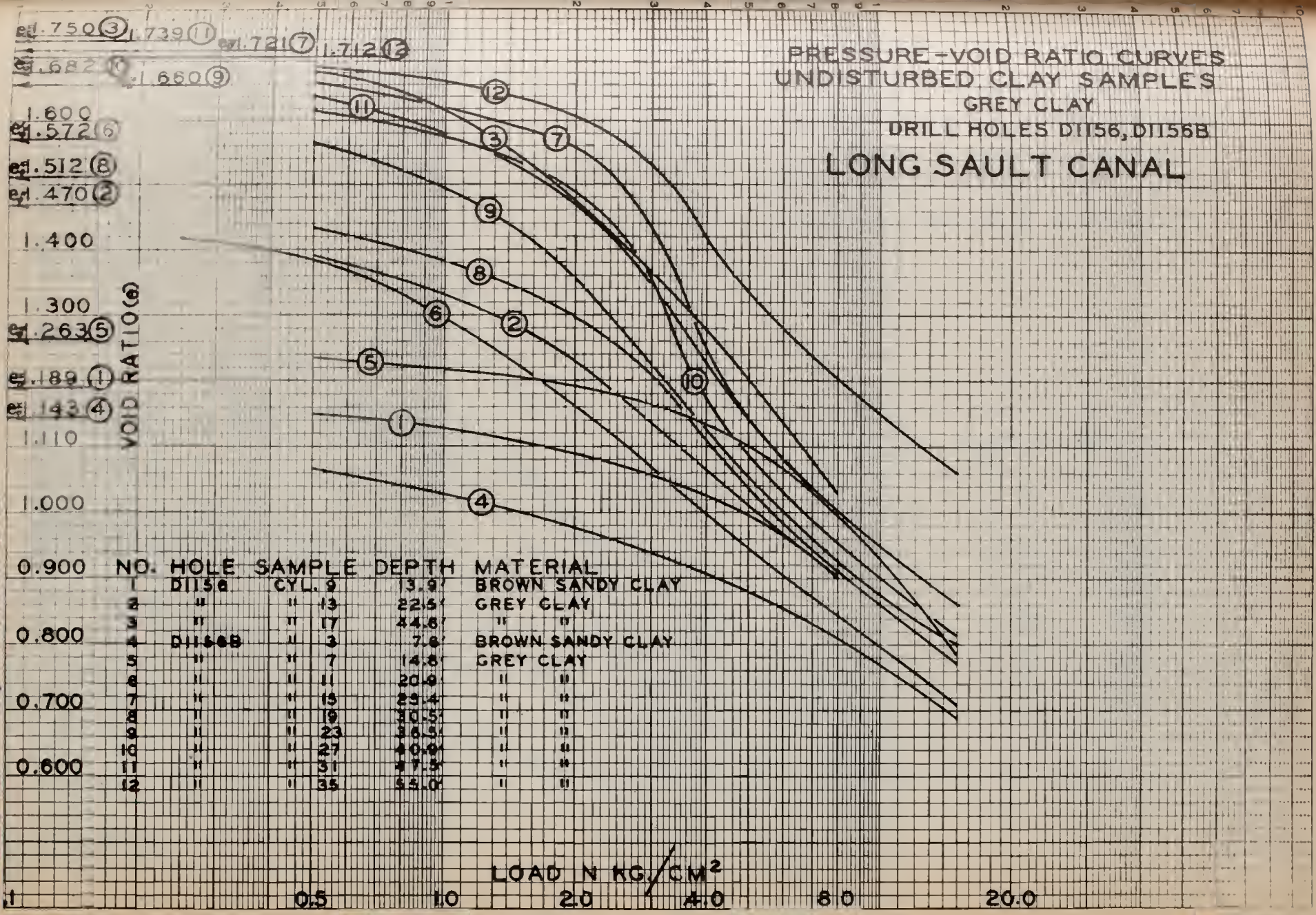


FILE NO. MC-A-2/58

PLATE III-71

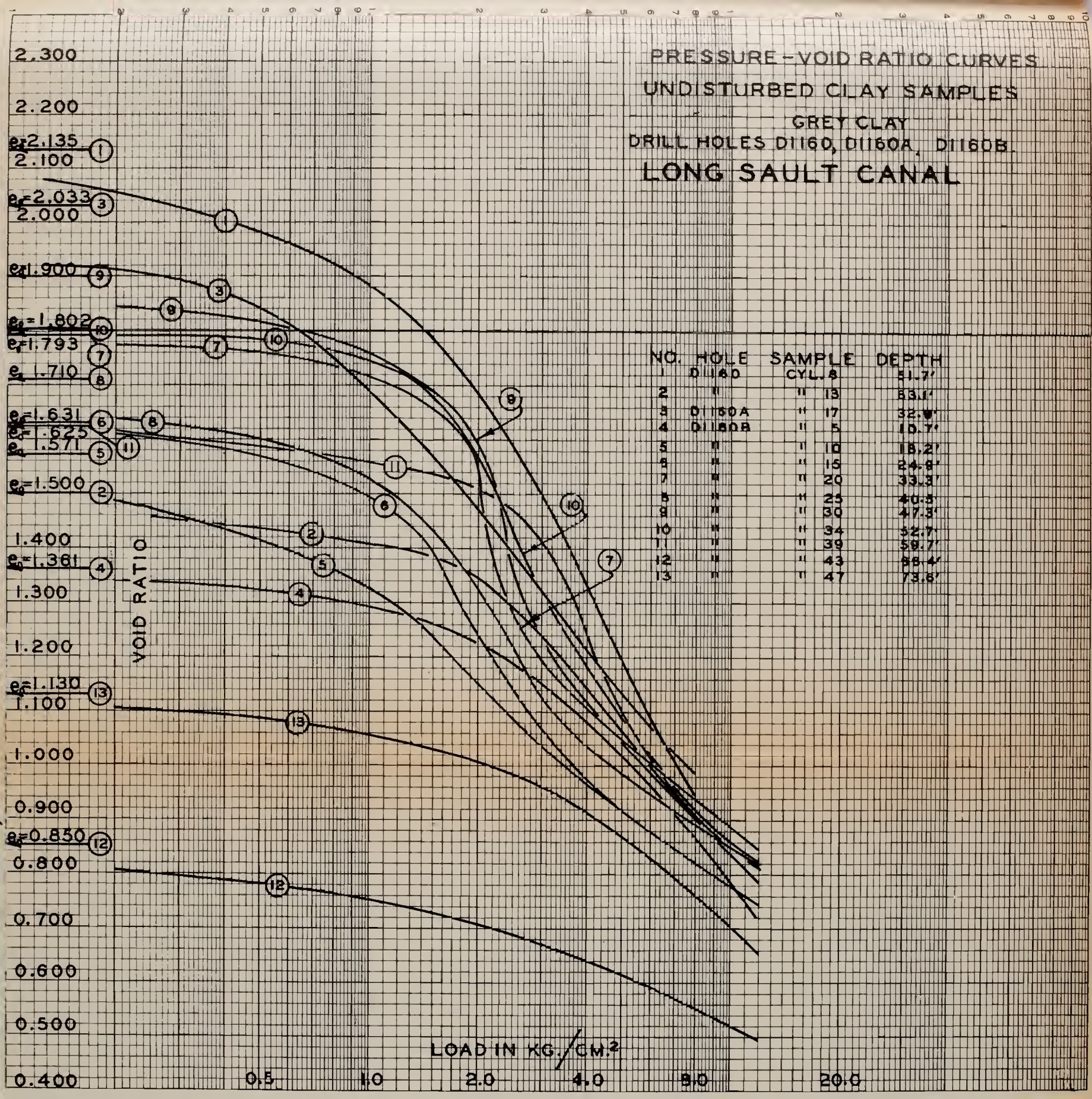
PRESSURE - VOID RATIO CURVES
UNDISTURBED CLAY SAMPLES
GREY CLAY
DRILL HOLES D1156, D1156B

LONG SAULT CANAL



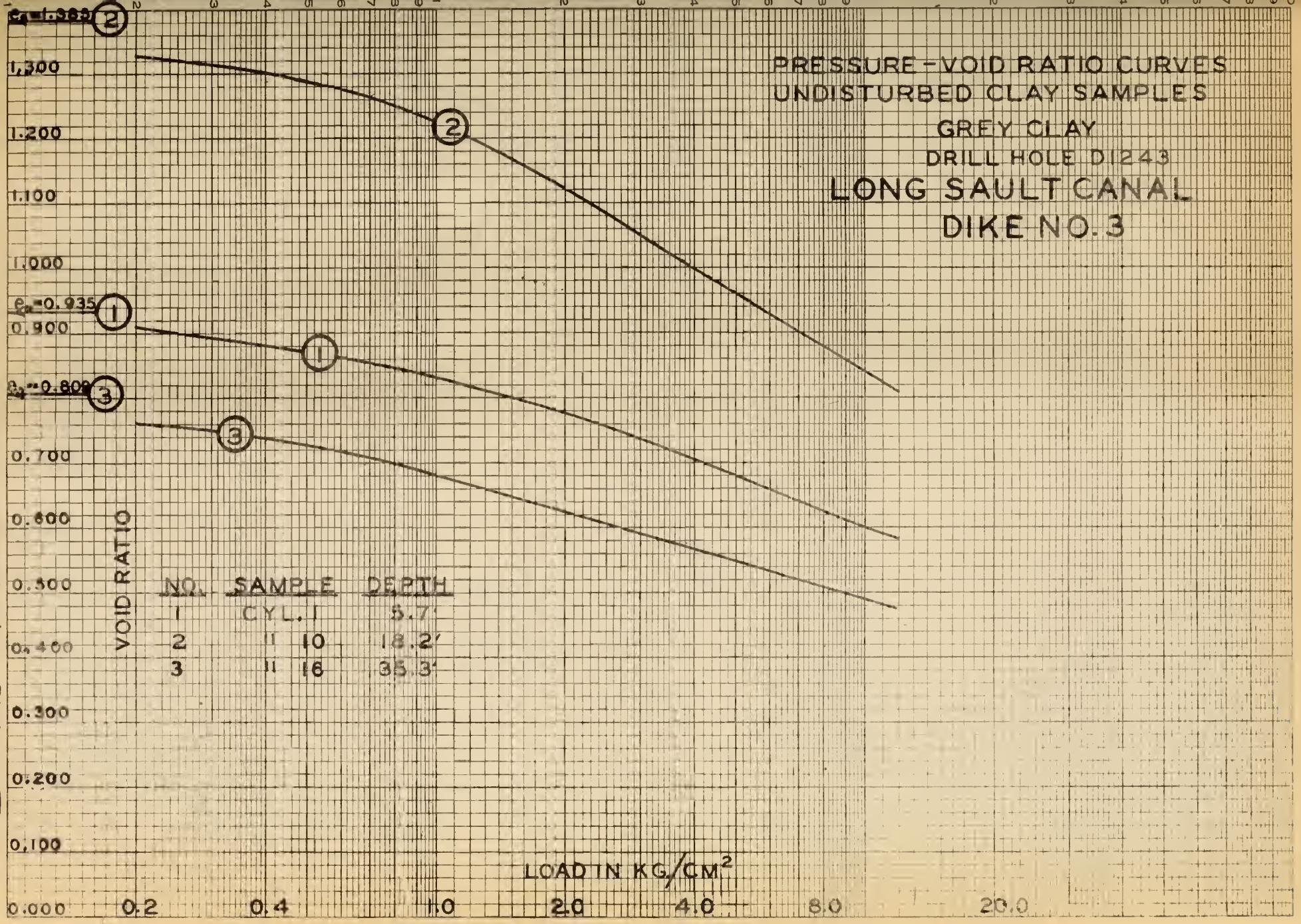
NO.	HOLE	SAMPLE		DEPTH	MATERIAL
1	D1156	CYL.	9	13.9'	BROWN SANDY CLAY
2	"	"	13	22.5'	GREY CLAY
3	"	"	17	44.6'	" "
4	D1156B	"	3	7.6'	BROWN SANDY CLAY
5	"	"	7	14.8'	GREY CLAY
6	"	"	11	20.9'	" "
7	"	"	15	29.4'	" "
8	"	"	19	30.5'	" "
9	"	"	23	36.5'	" "
10	"	"	27	40.0'	" "
11	"	"	31	47.5'	" "
12	"	"	35	55.0'	" "

FILE NO MC-A-2/59 PLATE III-72

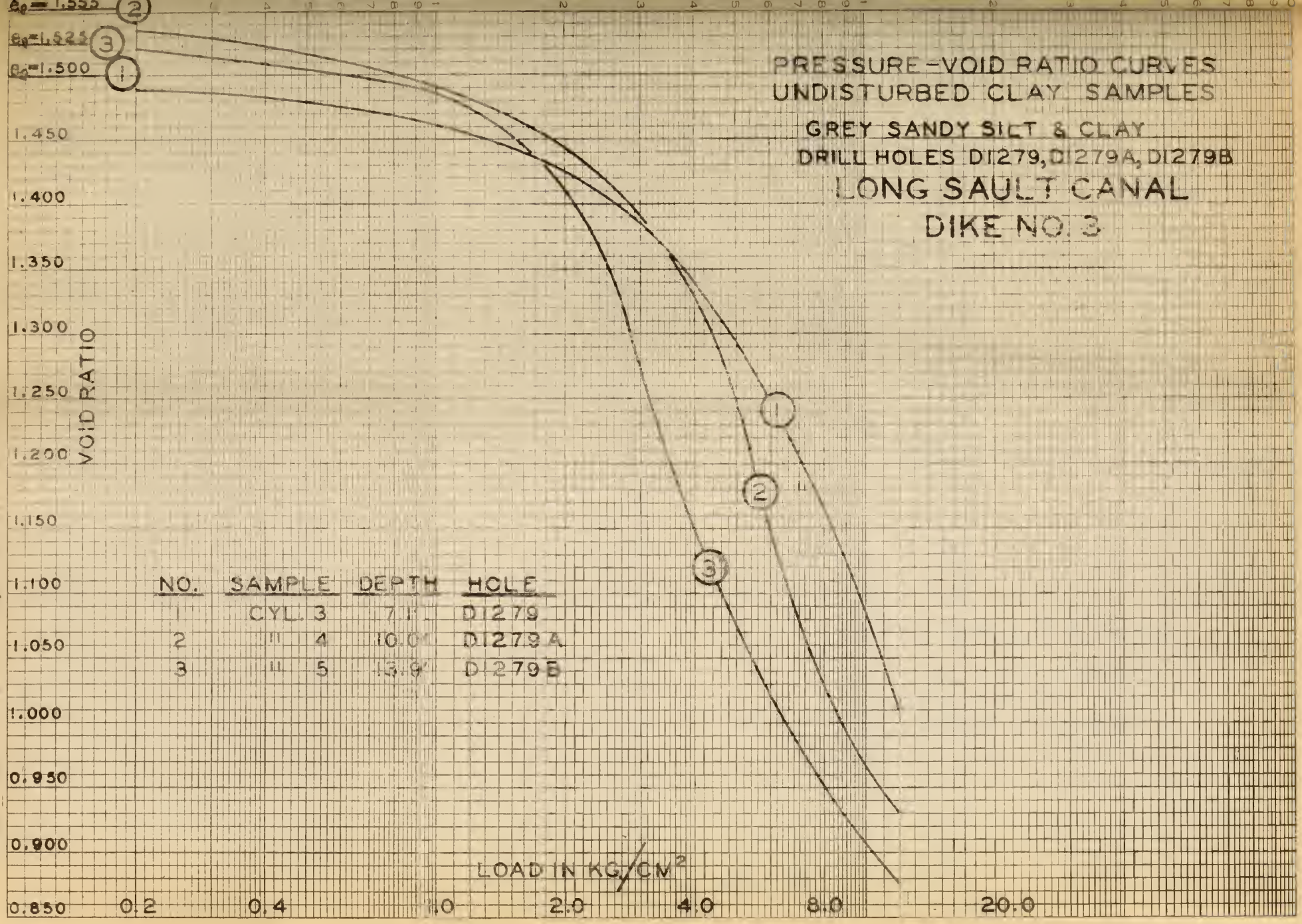


FILE NO. MC-A-2/60

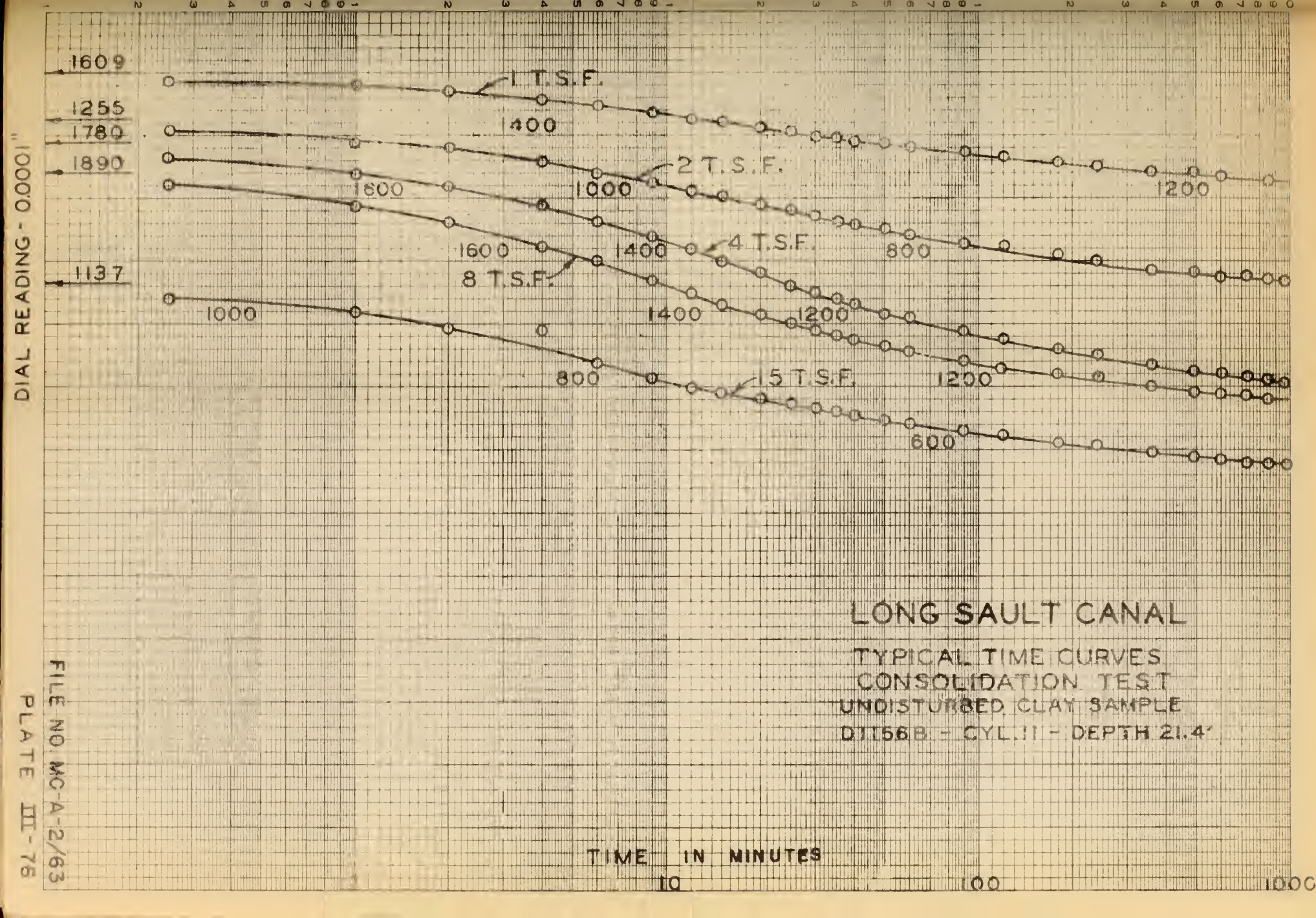
PLATE III - 73

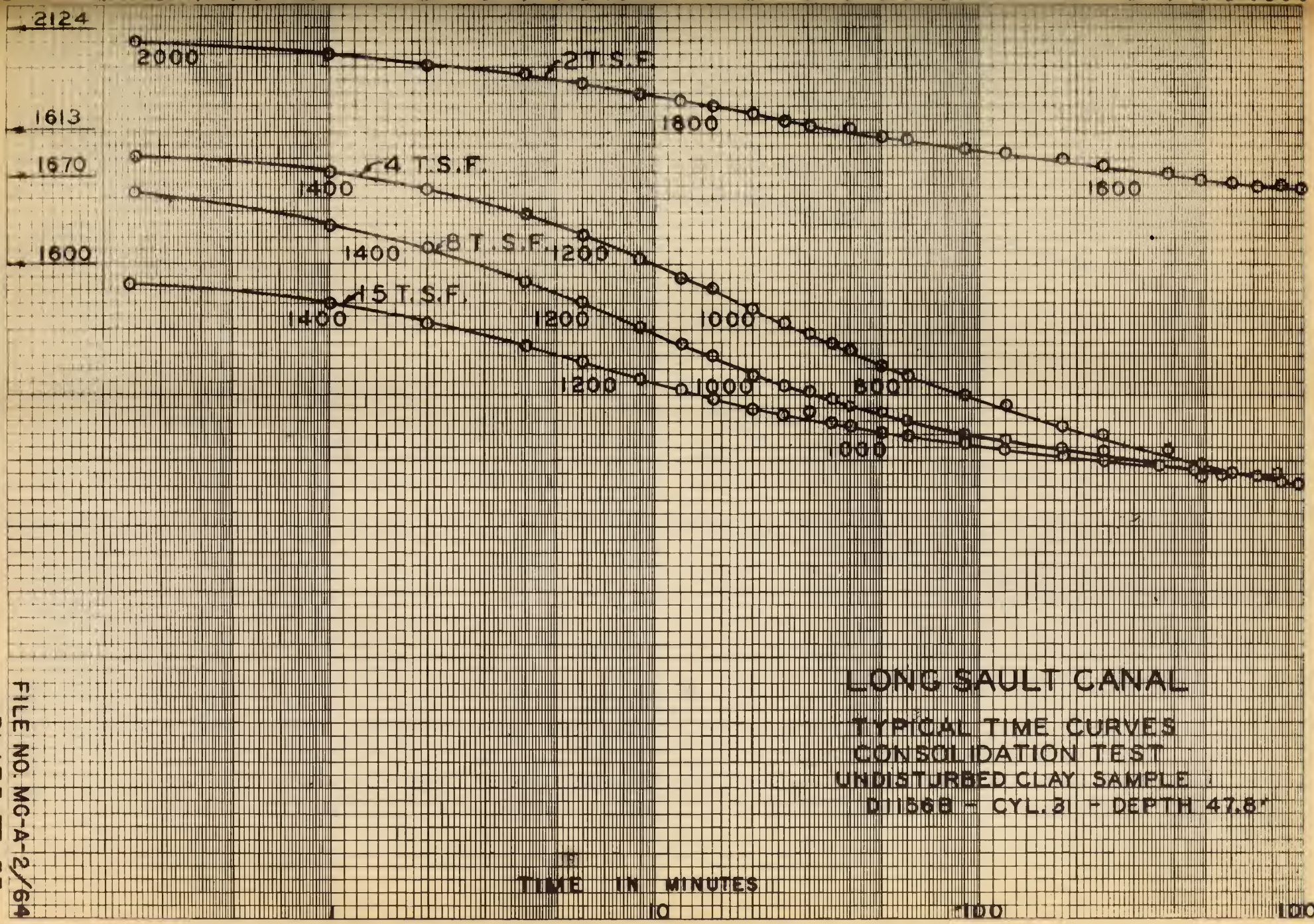


FILE NO. MC-A-2/61 PLATE III - 74



FILE NO. MC-A-2/62 PLATE III-75


1609
1255
1780
1890
1137
1 T.S.F.
400
2 T.S.F.
1000
1200
1600
4 T.S.F.
1400
800
8 T.S.F.
1600
1000
1400
1200
1.5 T.S.F.
800
1200
600
DIAL READING - 0.0001"
TIME IN MINUTES
10
100
1000
LONG SAULT CANAL
TYPICAL TIME CURVES
CONSOLIDATION TEST
UNDISTURBED CLAY SAMPLE
DT56B - CYL. II - DEPTH 21.4'
FILE NO. MC-A-2/63
PLATE III-75


2124
1613
1570
1600
DIAL READING - 0.0001"
2000
2 T.S.F.
1800
4 T.S.F.
1400
1600
8 T.S.F.
1400
1200
15 T.S.F.
1400
1200
1000
1200
1000
800
1000
TIME IN MINUTES
1
10
100
1000
LONG SAULT CANAL
TYPICAL TIME CURVES
CONSOLIDATION TEST
UNDISTURBED CLAY SAMPLE
D1568 - CYL. 31 - DEPTH 47.8'
FILE NO. MC-A-2/64
PLATE III-77

LONG SAULT CANAL

TYPICAL TIME CURVES
CONSOLIDATION TEST
UNDISTURBED CLAY SAMPLE
DI 1608 - CYL. 15 - DEPTH 25.2'

0.8 T.S.F.
1.5 T.S.F.
3 T.S.F.
6 T.S.F.
12 T.S.F.

2033
2430
1736
2664
1805

TIME IN MINUTES

DIAL READING - 0.0001"

FILE NO. MC-A-2/65

PLATE III-78

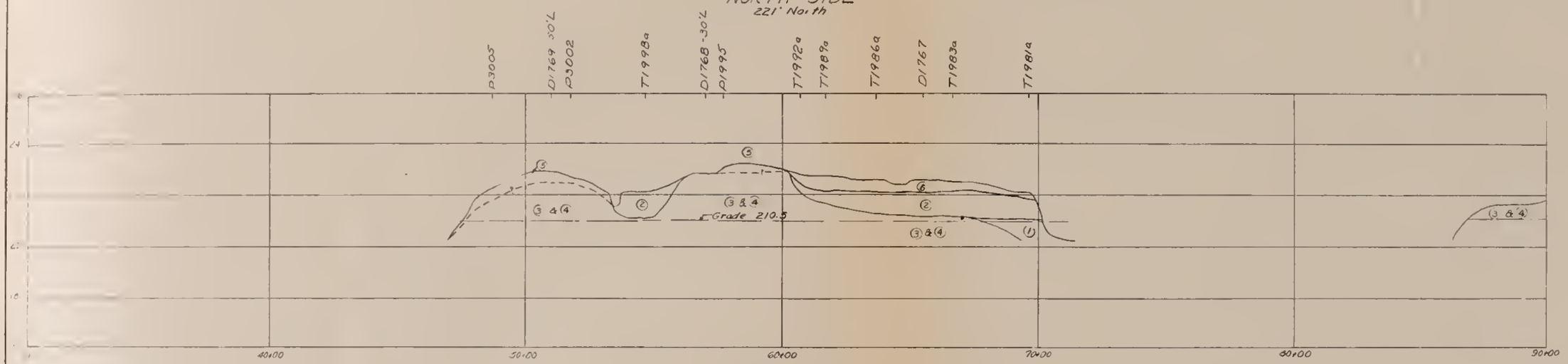
LONG SAULT CANAL
TYPICAL TIME CURVES
CONSOLIDATION TEST
UNDISTURBED CLAY SAMPLE
DI1608 - CYL. 30 - DEPTH 47'-8"
0.8 T.S.F.
1.5 T.S.F.
3 T.S.F.
6 T.S.F.
12 T.S.F.
TIME IN MINUTES
DIAL READING - 0.0001"
2502
2257
1811
2618
1609
FILE NO MC-A-2/66

PLATE III-79

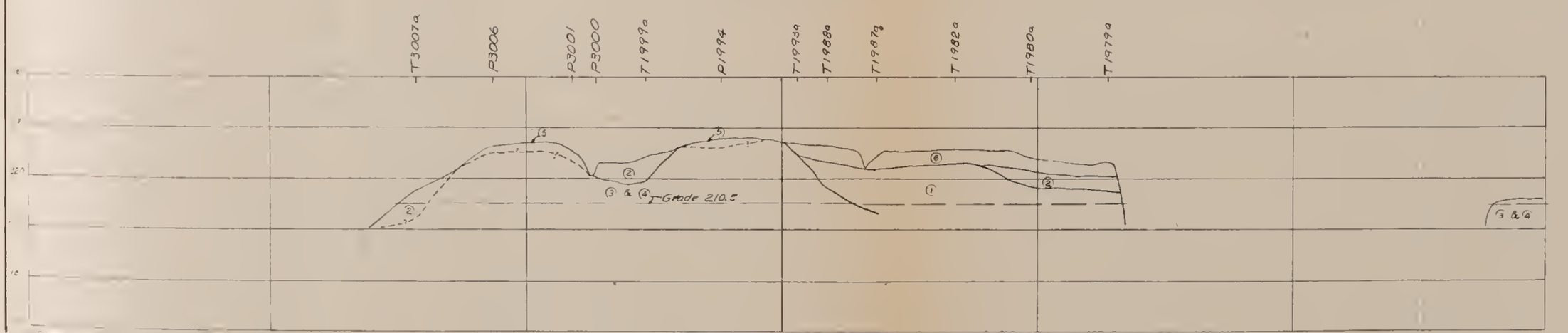
FILE NO. MC-A-2/67

PLATE III-80

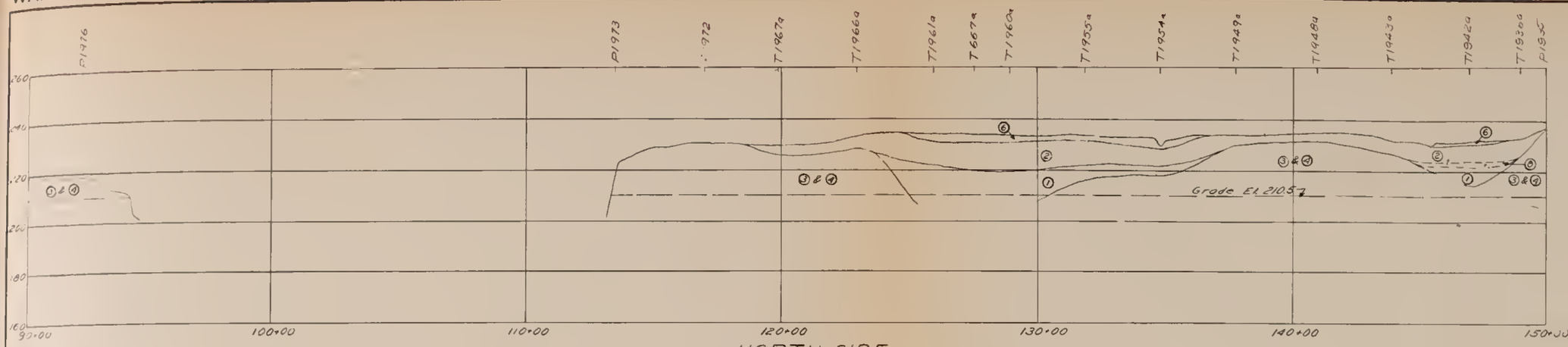
NORTH SIDE
221' North

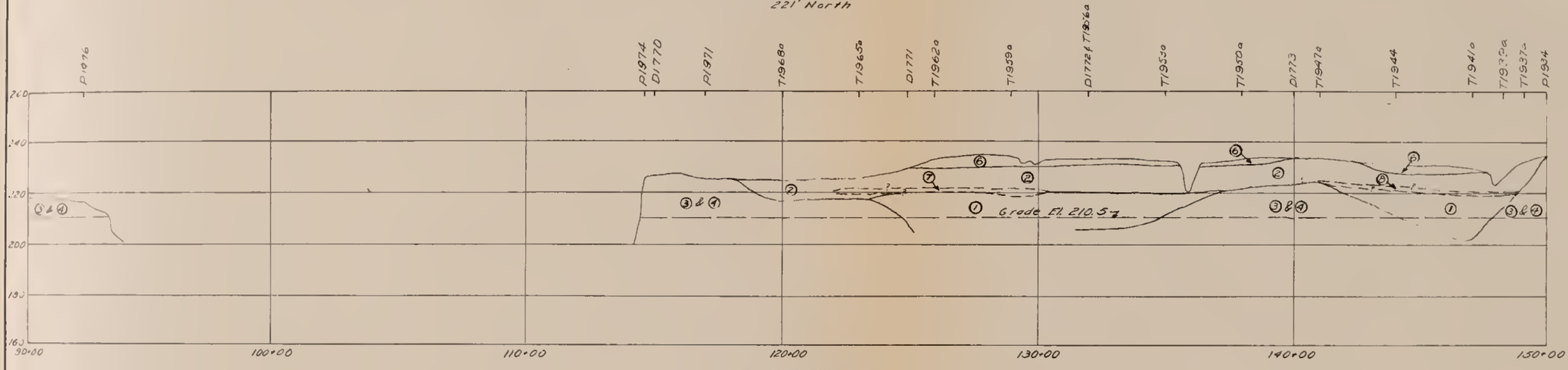


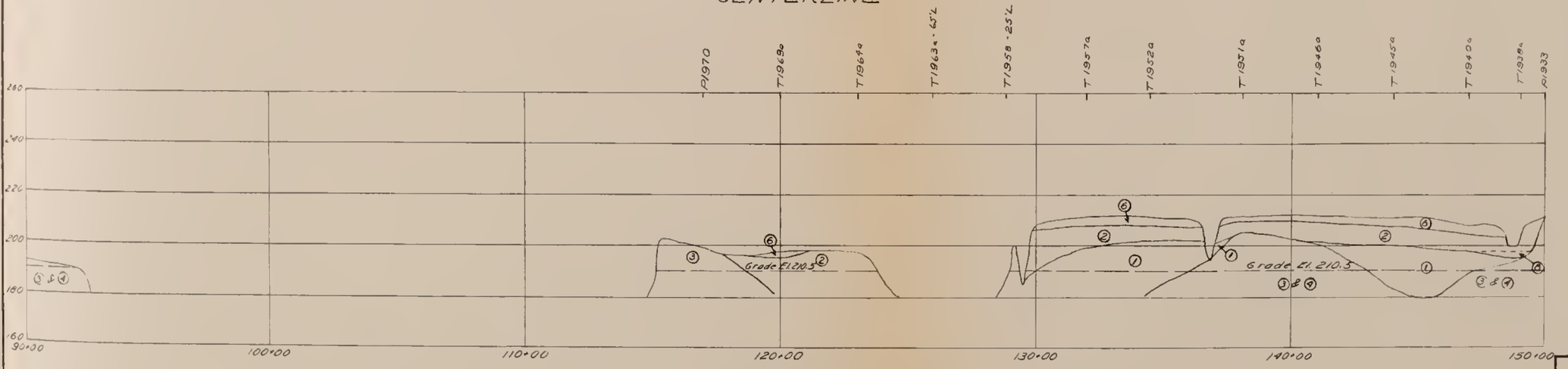
CENTER LINE



LEGEND
① SOFT GRAY
② VARIABLE
③ COMPACT,
SCATTERE
④ FAIRLY CO
SCATTERE
⑤ LOOSE VA
⑥ UNIFORM
⑦ STRATIFIE
⑧ VARIABLE
—?— BOUNDARY







LEGEND

1. SOFT GRAY CLAY
2. VARIABLE SANDY CLAY
3. COMPACT, CLAYEY OR SILTY, GRAVELLY SAND SCATTERED BOULDERS
4. FAIRLY COMPACT, VARIABLE SILTY GRAVELLY SAND SCATTERED BOULDERS
5. LOOSE VARIABLE SILTY AND GRAVELLY SAND
6. UNIFORM SILTY FINE TO MEDIUM SAND
7. STRATIFIED SAND
8. VARIABLE SAND AND GRAVEL

—?— BOUNDARY UNCERTAIN BECAUSE OF INSUFFICIENT DATA

SCALE: 1"=200' HORIZONTAL
1"=20' VERTICAL

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
GEOLOGICAL PROFILES
STA 90+00 TO STA. 150+00

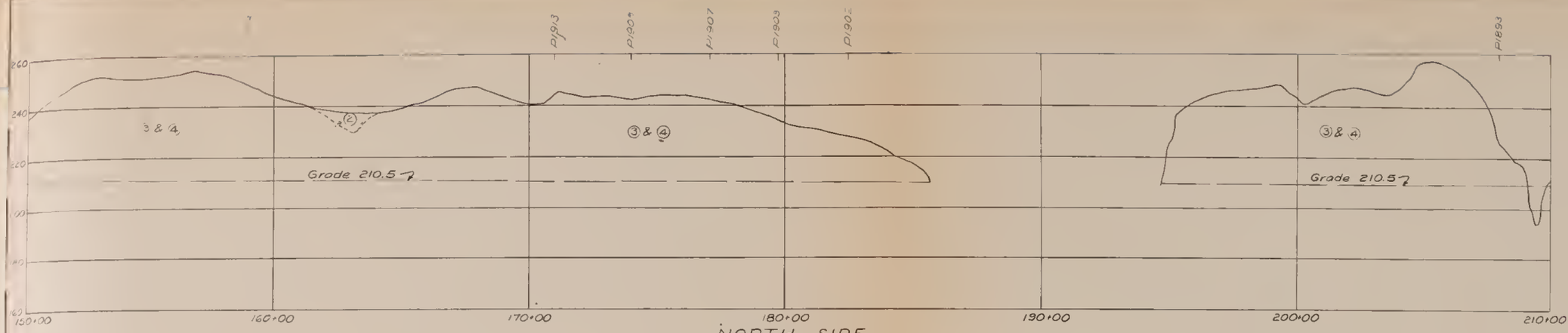
IN SHEETS	SHEET NO.	SCALE AS SHOWN
20	0	20' VERTICAL
300	9	400' HORIZONTAL

U. S ENGINEER OFFICE, MASSENA, NEW YORK FEB 1942

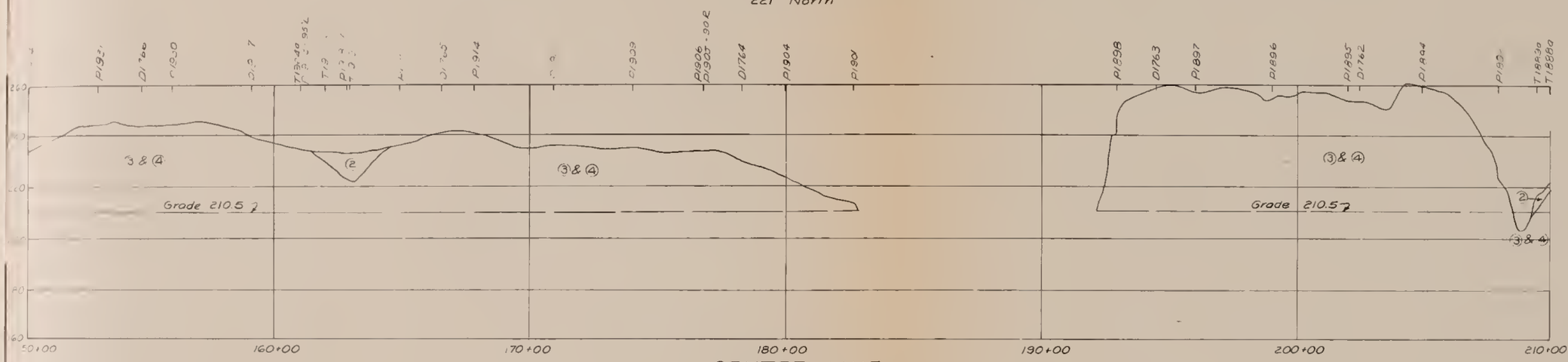
SUBMITTED	RECOMMENDED	APPROVED
R M. Hamer, ENGINEER	L. Sullivan, LT. COL., CORPS OF ENGINEERS	COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY	CHECKED BY GPB	FILE NO MC A-2/69	TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 194

PLATE IV-2



NORTH SIDE
221' North



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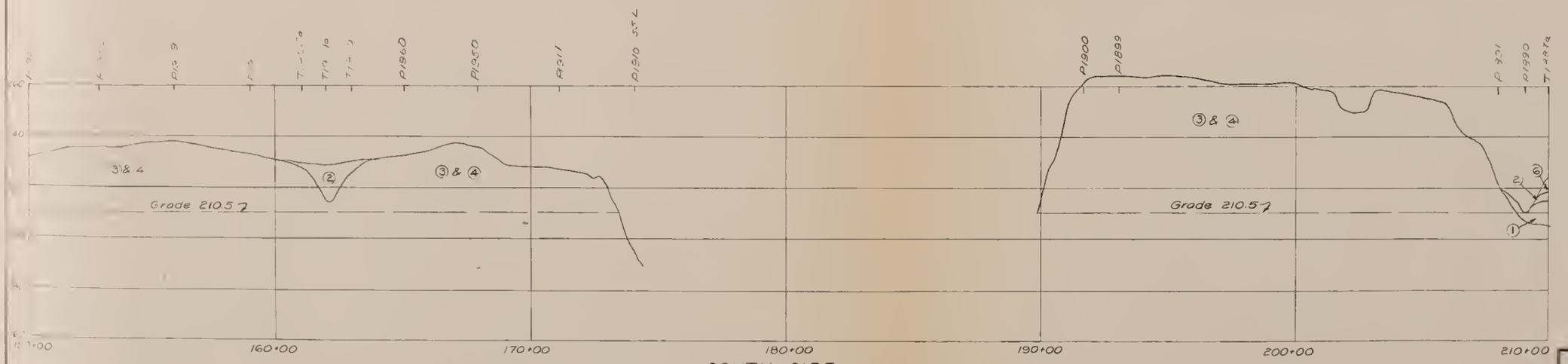


SOUTH SIDE
221' South

LEGEND
① SOFT GRAY CLAY
② VARIABLE SANDY CLAY
③ COMPACT, CLAYEY OR SILTY, GRAVELLY SAND SCATTERED BOULDERS
④ FAIRLY COMPACT, VARIABLE SILTY GRAVELLY SAND SCATTERED BOULDERS
⑤ LOOSE VARIABLE SILTY AND GRAVELLY SAND
⑥ UNIFORM SILTY FINE TO MEDIUM SAND
⑦ STRATIFIED SAND
⑧ VARIABLE SAND AND GRAVEL
-?- BOUNDARY UNCERTAIN BECAUSE OF INSUFFICIENT DATA

SCALE: 1"=200' HORIZONTAL
1"=20' VERTICAL

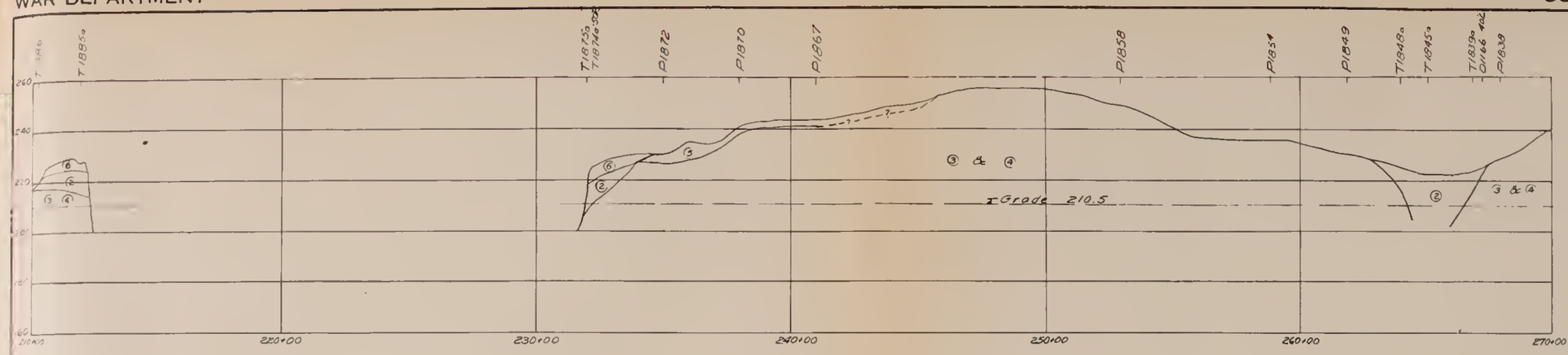
ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
GEOLOGICAL PROFILES
STA. 150+00 TO STA. 210+00

IN SHEETS	SHEET NO	SCALE AS SHOWN

U S ENGINEER OFFICE MASSENA, NEW YORK FEB. 1942

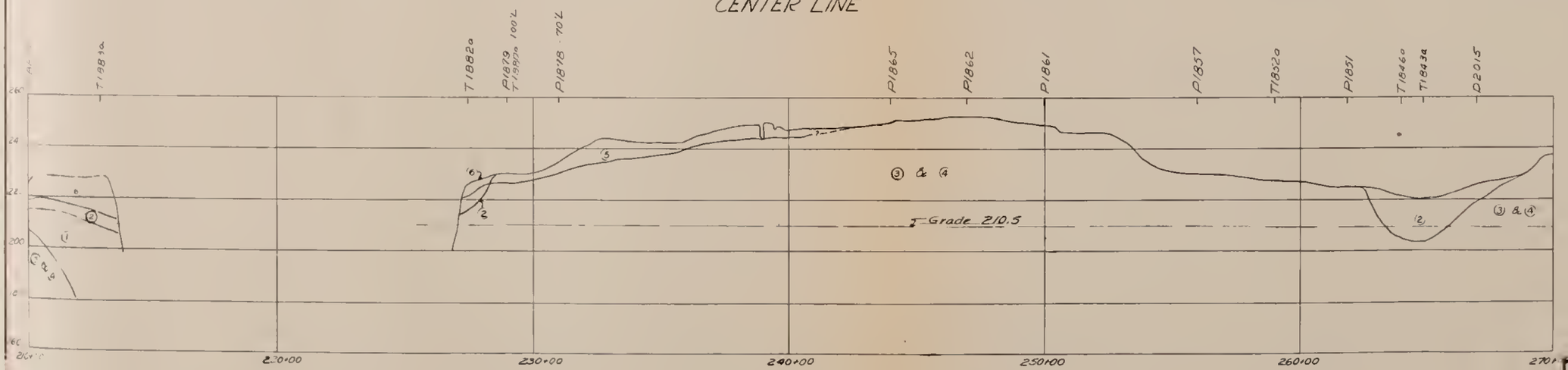
SUBMITTED	RECOMMENDED	APPROVED
R M Hamer, ENGINEER	E. Sullivan, LT. COL. CORPS OF ENGINEERS, DIST. ENGR	A. R. Mimer, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY	CHECKED BY GFB	FILE NO MC-A-2/70	TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 194



NORTH SIDE
221' North

CENTER LINE



SOUTH SIDE
221' South.

SCALE. 1"=200' HORIZONTAL
1"=20' VERTICAL

LEGEND
① SOFT GRAY CLAY
② VARIABLE SANDY CLAY
③ COMPACT, CLAYEY OR SILTY, GRAVELLY SAND SCATTERED BOULDERS
④ FAIRLY COMPACT, VARIABLE SILTY GRAVELLY SAND SCATTERED BOULDERS
⑤ LOOSE VARIABLE SILTY AND GRAVELLY SAND
⑥ UNIFORM SILTY FINE TO MEDIUM SAND
⑦ STRATIFIED SAND
⑧ VARIABLE SAND AND GRAVEL
-?- BOUNDARY UNCERTAIN BECAUSE OF INSUFFICIENT DATA

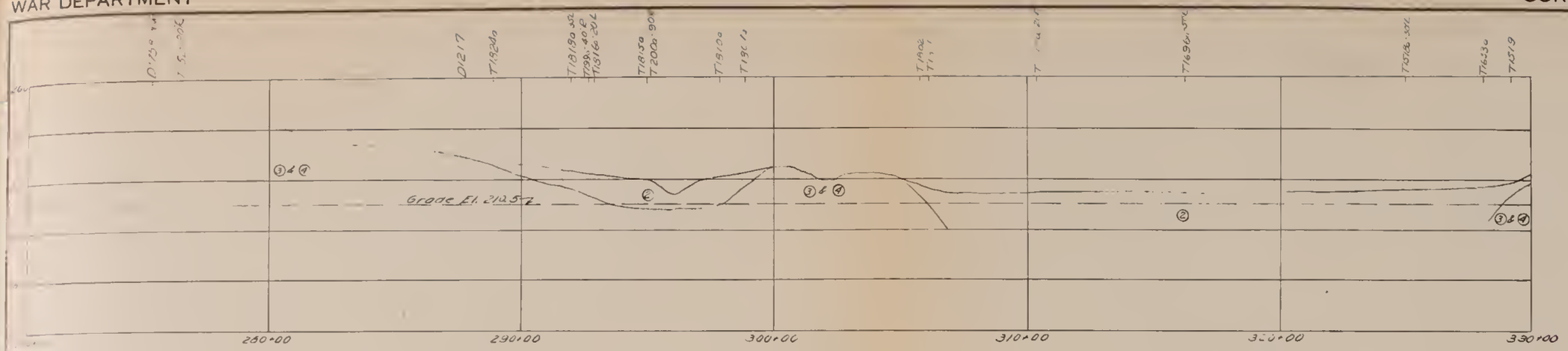
ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
GEOLOGICAL PROFILES
STA. 210+00 TO STA. 270+00

IN SHEETS	SHEET NO	SCALE AS SHOWN
		40' 0 40' 80' VERTICAL; 200' 0 200' 400' HORIZONTAL

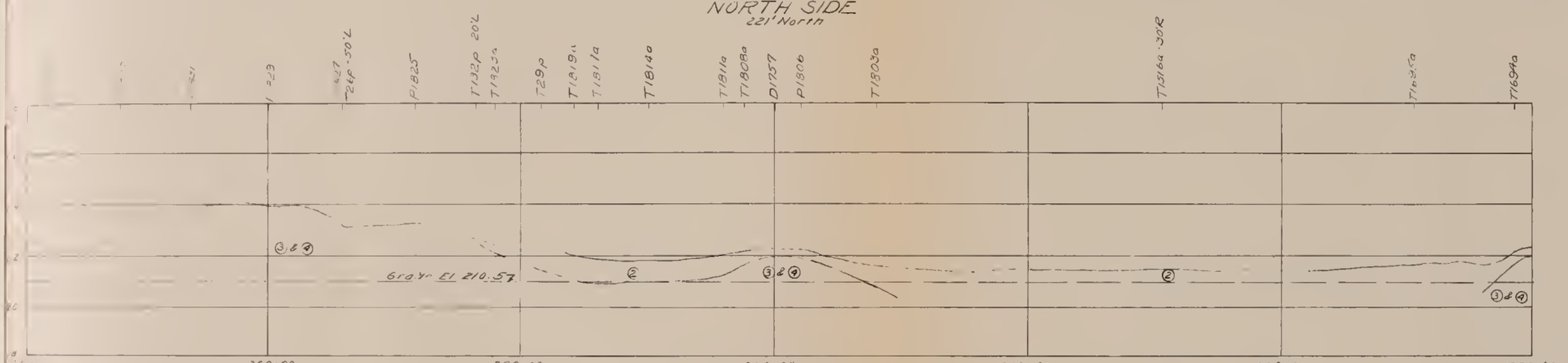
U. S. ENGINEER OFFICE, MASSENA, NEW YORK FEB. 1942

SUBMITTED	RECOMMENDED	APPROVED
R M Hamm, ENGINEER	[signature], LT. COL. CORPS OF ENGINEERS, DIST. ENGINEER	[signature], COL. CORPS OF ENGINEERS, DIVISION ENGINEER

DRAWN BY
CHECKED BY GEE
FILE NO MC-A-2/71
TRANSMITTED WITH LETTER OF ENDORSEMENT DATED 194



NORTH SIDE
221' North



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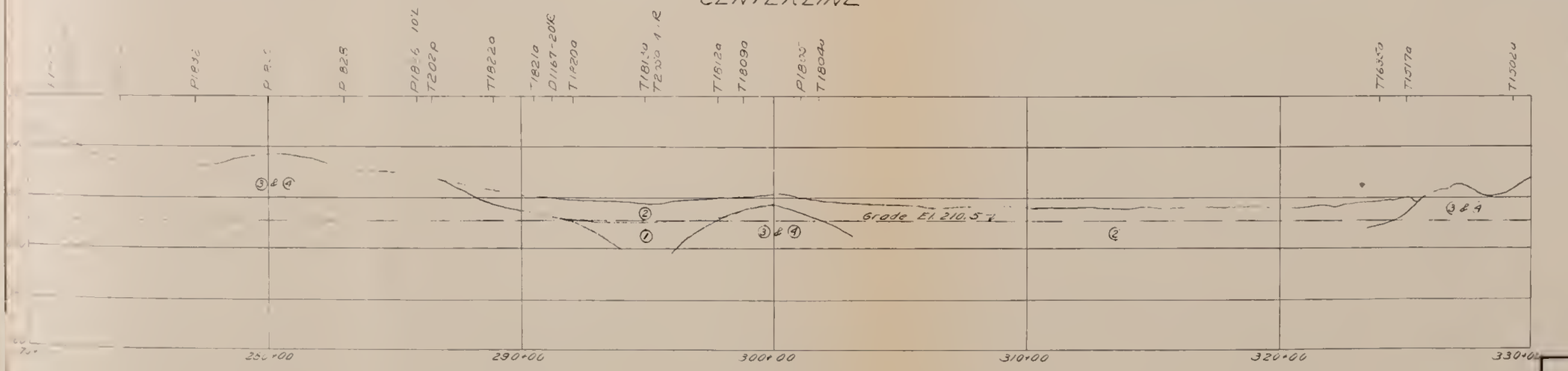


SOUTH SIDE
221' South

LEGEND:
① SOFT GRAY CLAY
② VARIABLE SANDY CLAY
③ COMPACT, CLAYEY OR SILTY, GRAVELLY SAND SCATTERED BOULDERS
④ FAIRLY COMPACT, VARIABLE SILTY GRAVELLY SAND SCATTERED BOULDERS
⑤ LOOSE VARIABLE SILTY AND GRAVELLY SAND
⑥ UNIFORM SILTY FINE TO MEDIUM SAND
⑦ STRATIFIED SAND
⑧ VARIABLE SAND AND GRAVEL
—?— BOUNDARY UNCERTAIN BECAUSE OF INSUFFICIENT DATA

SCALE. 1"=200' HORIZONTAL
1"=20' VERTICAL

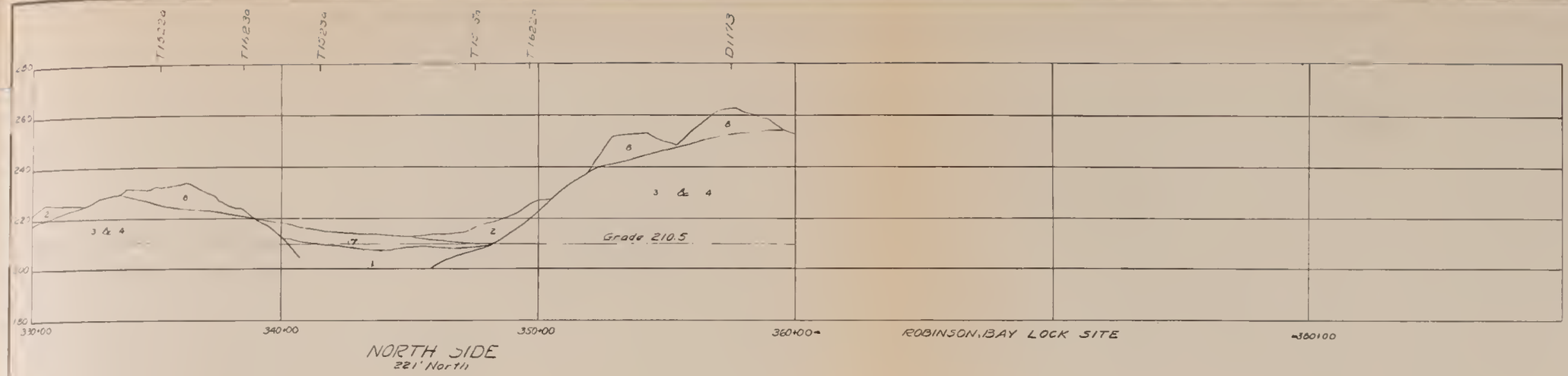
ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
GEOLOGICAL PROFILES
STA. 270+00 TO STA. 330+00

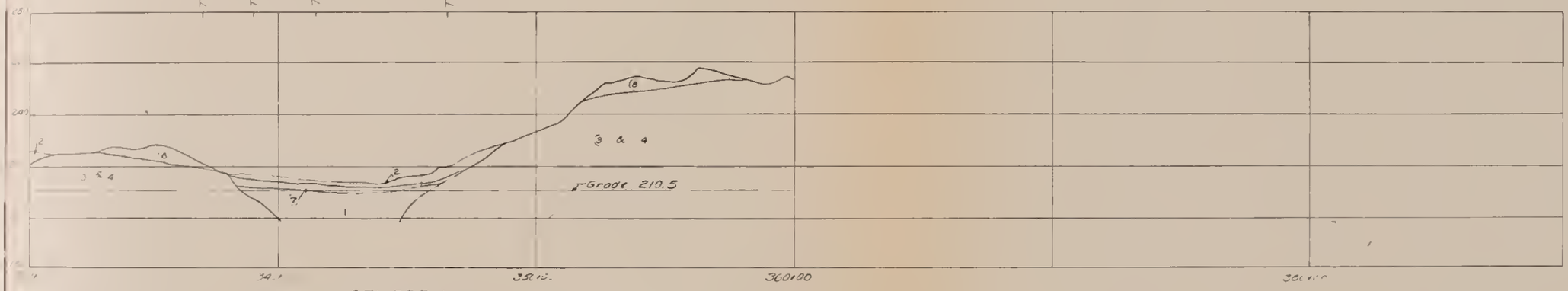
IN SHEETS | SHEET NO | SCALE AS SHOWN

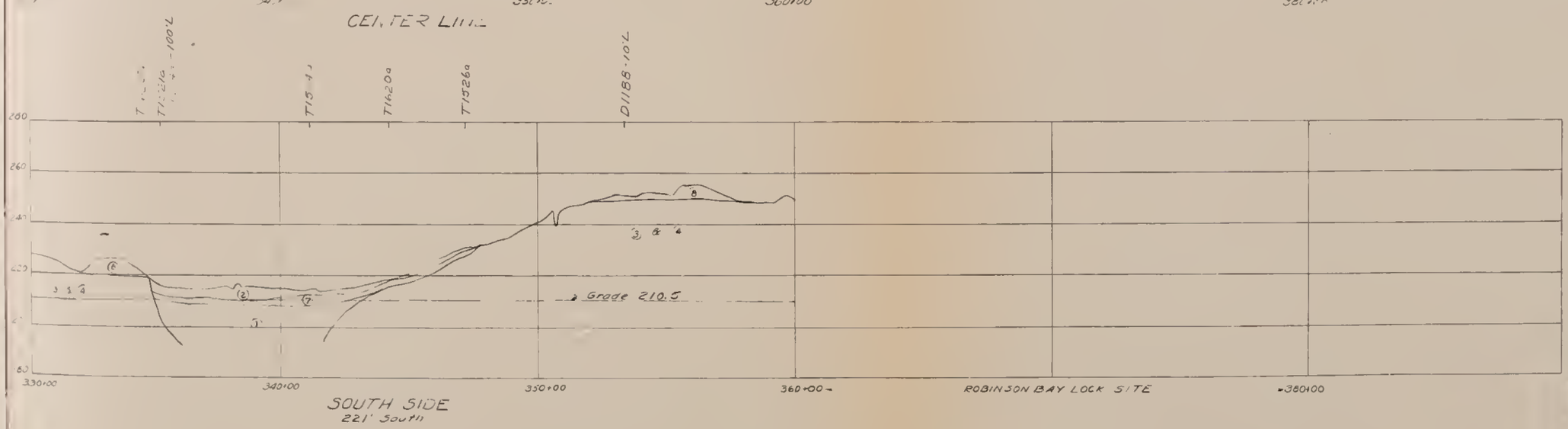
U. S. ENGINEER OFFICE, MASSENA, NEW YORK FEB 1942

SUBMITTED: R. M. Harmon, ENGINEER
RECOMMENDED: [signature], Asst. U.S.C. CORPS OF ENGINEERS
APPROVED: [signature], COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY | CHECKED BY G.B.B. | FILE NO NK 2-217 | TRANSMITTED WITH LETTER OR ENDORSEMENT DATED







LEGEND:
1. SOFT GRAY CLAY
2. VARIABLE SANDY CLAY
3. COMPACT, CLAYEY OR SILTY, GRAVELLY SAND SCATTERED BOULDERS
4. FAIRLY COMPACT, VARIABLE SILTY GRAVELLY SAND SCATTERED BOULDERS
5. LOOSE VARIABLE SILTY AND GRAVELLY SAND
6. UNIFORM SILTY FINE TO MEDIUM SAND
7. STRATIFIED SAND
8. VARIABLE SAND AND GRAVEL

-?- BOUNDARY UNCERTAIN BECAUSE OF INSUFFICIENT DATA

SCALE 1"=200' HORIZONTAL
1"=20' VERTICAL

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
GEOLOGICAL PROFILES
STA. 330+00 TO STA. 360+00

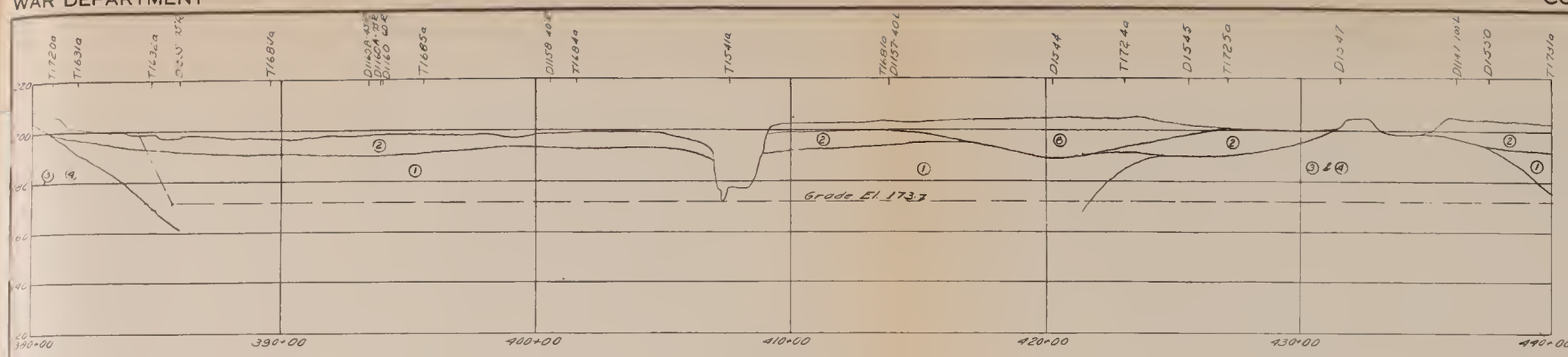
IN 1 SHEETS | SHEET NO. | SCALE AS SHOWN
200' 0 200' 400' VERTICAL
100' 0 100' 200' HORIZONTAL

U. S. ENGINEER OFFICE, MASSENA, NEW YORK FEB. 1942

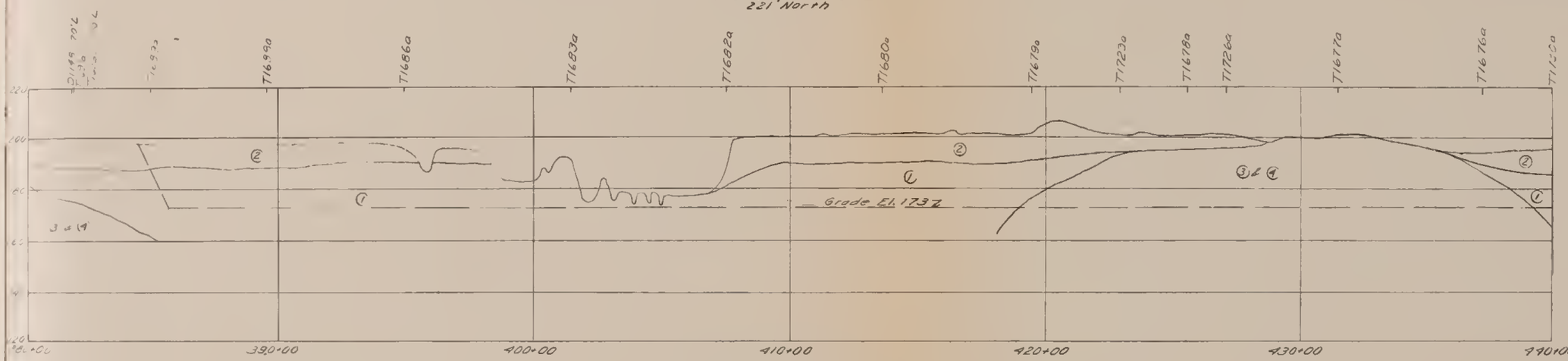
SUBMITTED	RECOMMENDED	APPROVED
P. M. Hanes, ENGINEER	LT. COL. CORPS OF ENGINEERS	COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY | CHECKED BY G.E.S. | FILE NO. VIC-A-2/73 | TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 194

PLATE IV-5



NORTH SIDE
221' North



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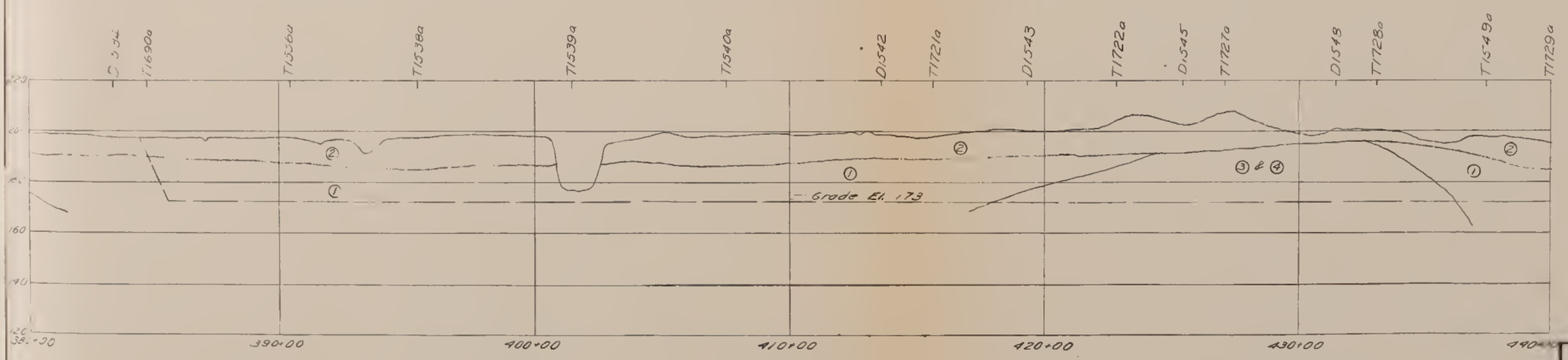


SOUTH SIDE
221' South

SCALE: 1"=200' HORIZONTAL
1"=20' VERTICAL

LEGEND
① SOFT GRAY CLAY
② VARIABLE SANDY CLAY
③ COMPACT, CLAYEY OR SILTY, GRAVELLY SAND SCATTERED BOULDERS
④ FAIRLY COMPACT, VARIABLE SILTY GRAVELLY SAND SCATTERED BOULDERS
⑤ LOOSE VARIABLE SILTY AND GRAVELLY SAND
⑥ UNIFORM SILTY FINE TO MEDIUM SAND
⑦ STRATIFIED SAND
⑧ VARIABLE SAND AND GRAVEL
-?- BOUNDARY UNCERTAIN BECAUSE OF INSUFFICIENT DATA

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
GEOLOGICAL PROFILES
STA 380+00 TO STA 440+00

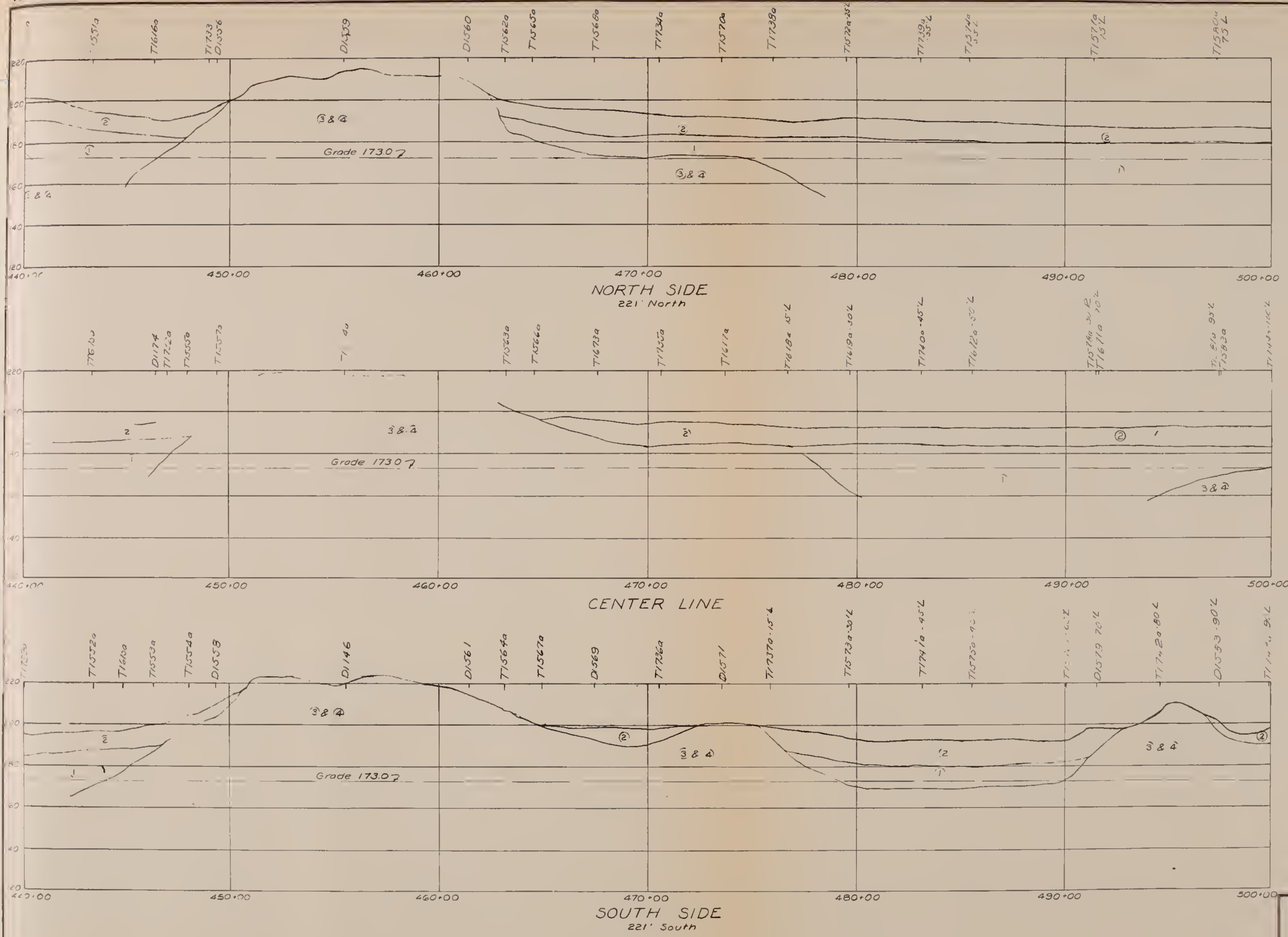
IN SHEETS	SHEET NO.	SCALE AS SHOWN
		20' 0 20' 40' VERTICAL / 200' 0 200' 400' HORIZONTAL

U. S. ENGINEER OFFICE, MASSENA, NEW YORK FEB 1942

SUBMITTED	RECOMMENDED	APPROVED
R M Hanna ENGINEER	E Sullivar LT. COL. CORPS OF ENGINEERS	DISTRICT ENGINEER

DRAWN BY	FILE NO MC-A-2/74	TRANSMITTED WITH LETTER OF
CHECKED BY G.E.S.		DATED

PLATE IV-7



LEGEND
1. SOFT GRAY CLAY
2. VARIABLE SANDY CLAY
3. COMPACT, CLAYEY OR SILTY, GRAVELLY SAND SCATTERED BOULDERS
4. FAIRLY COMPACT, VARIABLE SILTY GRAVELLY SAND SCATTERED BOULDERS
5. LOOSE VARIABLE SILTY AND GRAVELLY SAND
6. UNIFORM SILTY FINE TO MEDIUM SAND
7. STRATIFIED SAND
8. VARIABLE SAND AND GRAVEL
-?- BOUNDARY UNCERTAIN BECAUSE OF INSUFFICIENT DATA

SCALE: 1"=200' HORIZONTAL
1"=20' VERTICAL

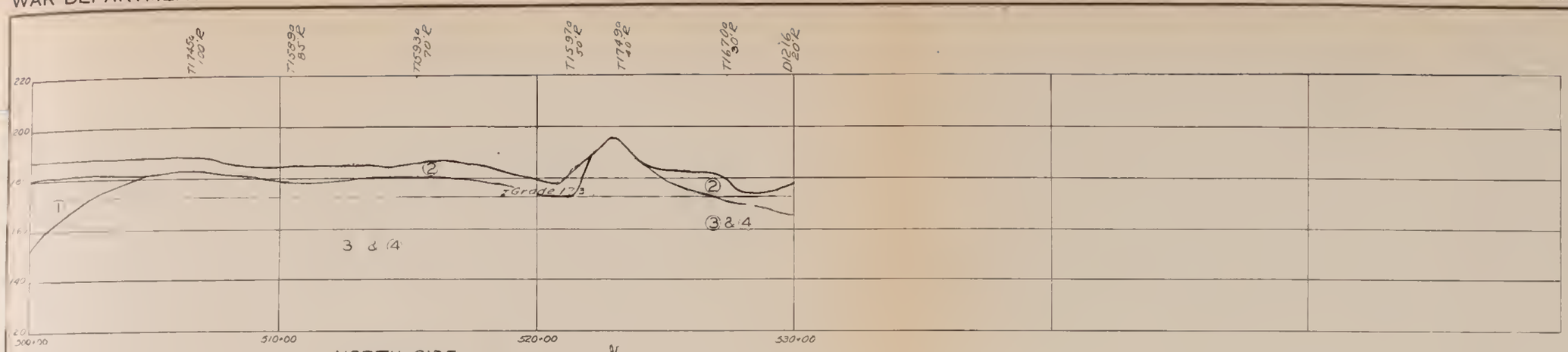
ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
GEOLOGICAL PROFILES
STA. 440+00 TO STA. 500+00

IN SHEETS SHEET NO SCALE AS SHOWN

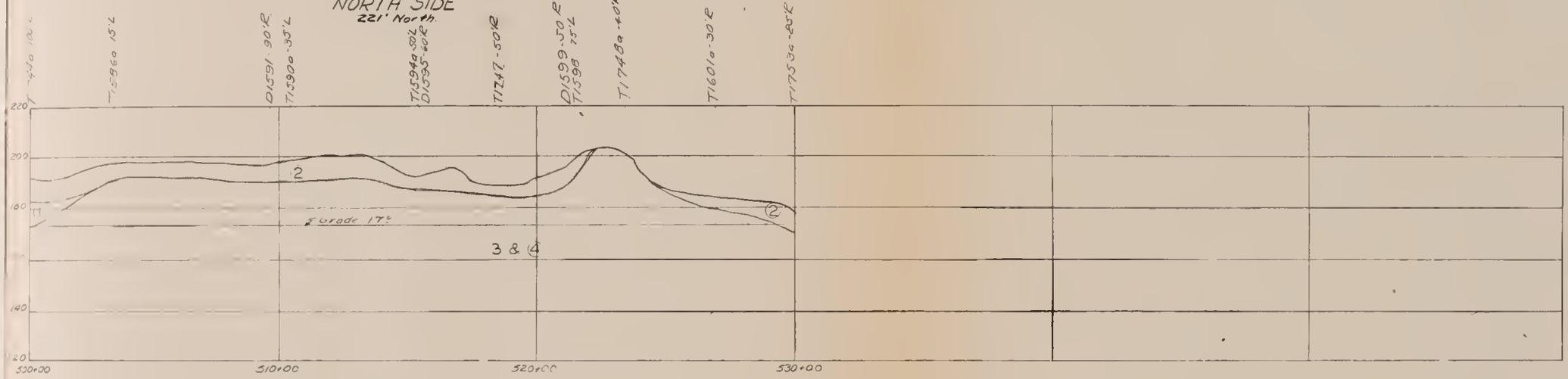
U. S. ENGINEER OFFICE, MASSENA, NEW YORK

SUBMITTED: R.M. Hansen, ENGINEER
RECOMMENDED: HEAD ENGR. ... CORPS OF ENGINEERS
APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY
CHECKED BY G.R.S.
FILE NO. MC-A-2/75
TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 194



NORTH SIDE
221' North.



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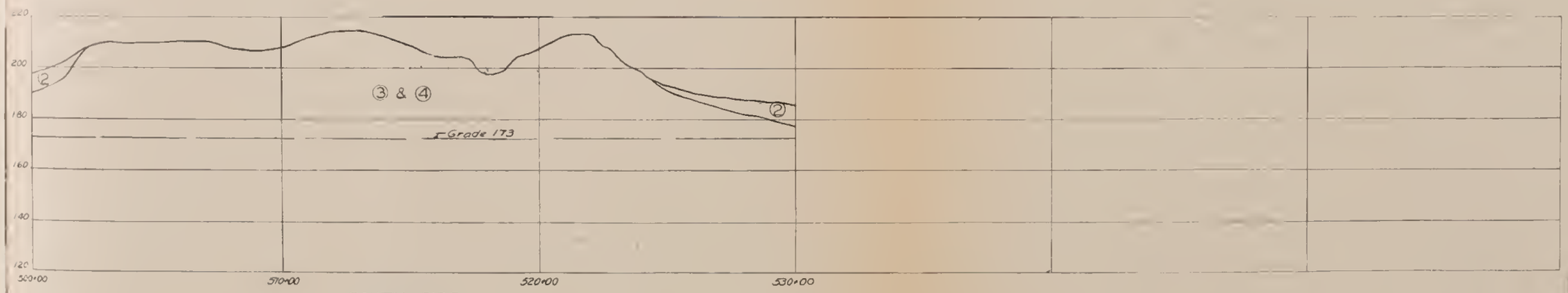


SOUTH SIDE
221' South

SCALE 1"=200' HORIZONTAL
1"=20 VERTICAL

LEGEND
① SOFT GRAY CLAY
② VARIABLE SANDY CLAY
③ COMPACT, CLAYEY OR SILTY, GRAVELLY SAND SCATTERED BOULDERS
④ FAIRLY COMPACT, VARIABLE SILTY GRAVELLY SAND SCATTERED BOULDERS
⑤ LOOSE VARIABLE SILTY AND GRAVELLY SAND
⑥ UNIFORM SILTY FINE TO MEDIUM SAND
⑦ STRATIFIED SAND
⑧ VARIABLE SAND AND GRAVEL
—?— BOUNDARY UNCERTAIN BECAUSE OF INSUFFICIENT DATA

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
GEOLOGICAL PROFILES
STA 500+00 TO STA 530+00

IN SHEETS	SHEET NO	SCALE AS SHOWN
20	0	

U S ENGINEER OFFICE, MASSENA, NEW YORK FEB 942

SUBMITTED	RECOMMENDED	APPROVED
R.M. Hamre ENGINEER	CORPS OF ENGINEERS	COL. CORPS OF ENGINEERS DISTRICT ENGINEER

DRAWN BY
CHECKED BY G.E.S.

FILE NO MC-A 2/76

TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 194

PLATE V-3

MECHANICAL ANALYSIS

SIEVE ANALYSIS — HYDROMETER ANALYSIS

SIZE OPENING IN INCHES — NO. MESH PER-INCH

"A" 2 | "B" 1.03 | "C" 0.742 | "D" 0.526 | "E" 0.371

100 | 26 | 16 | 8 | 4 | 3 | 4 | 6 | 8 | 10 | 14 | 20 | 28 | 35 | 48 | 65 | 100 | 150 | 200 | 250

% FINER BY WEIGHT

% RETAINED

90 80 70 60 50 40 30 20 10 0

0 10 20 30 40 50 60 70 80 90 100

NO.	HOLE	DEPTH	ELEV.
1	D1167	12.0'	206.4
2	"	22.5'	195.9
3	D1148	5.0'	194.7
4	"	22.0'	177.7
5	"	31.0'	168.7
6	"	46.0'	153.7
7	D1160A	33.0'	164.6

SITE .....
HOLE .....
DEPTH .....
SAMPLES .....
PLOTTER .....
DATE .....

LONG SAULT CANAL

TYPICAL OVERBURDEN MATERIALS.

GLACIAL TILL

BROWN SANDY CLAY

GREY CLAY

1000.0 500.0 300.0 200.0 100.0 50.0 30.0 20.0 10.0 5.0 3.0 2.0 1.0 0.5 0.3 0.2 0.1 0.05 0.03 0.02 0.01 0.005 0.003 0.002 0.001 0.0005 0.0002 0.0001

GRAIN SIZE IN MM.

M I T SOIL CLASSIFICATION

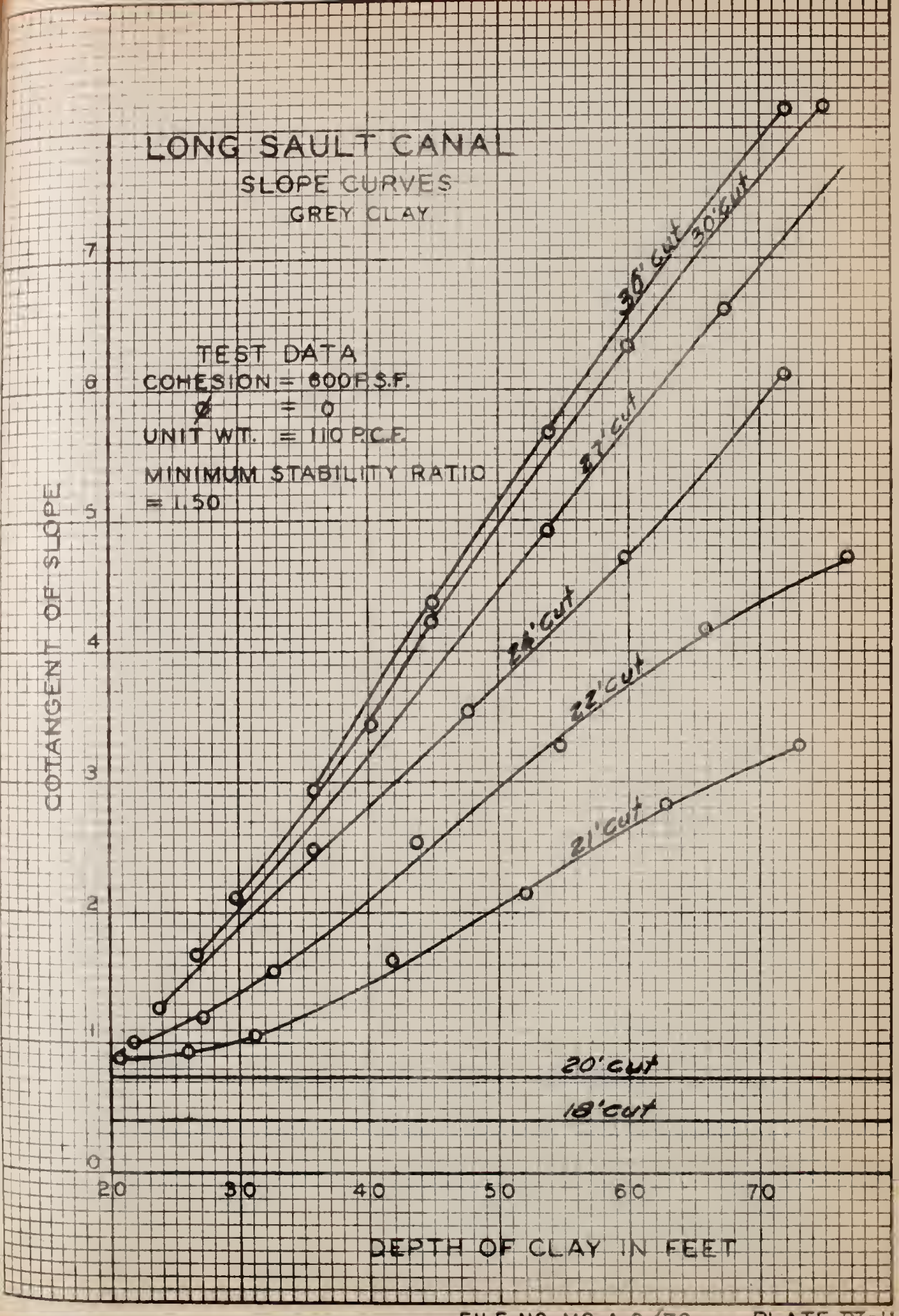
DERRICK	ONE MAN	SMALL	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	COLLOIDAL
STONE*			GRAVEL*			SAND			SILT			CLAY		

* These sizes not included in original M.I.T. Classification

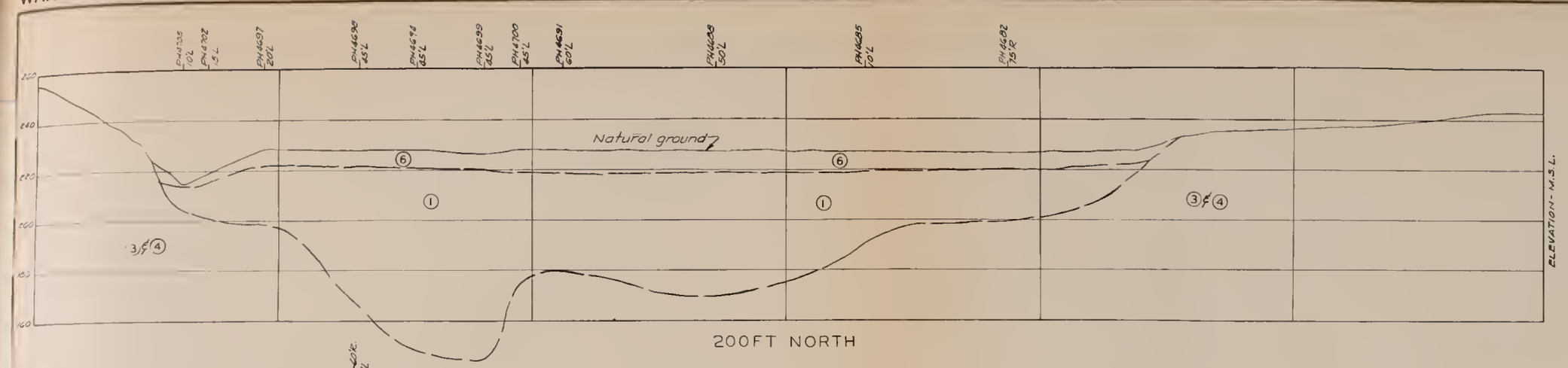
FILE NO. MC-A-2/77

PLATE IV-10

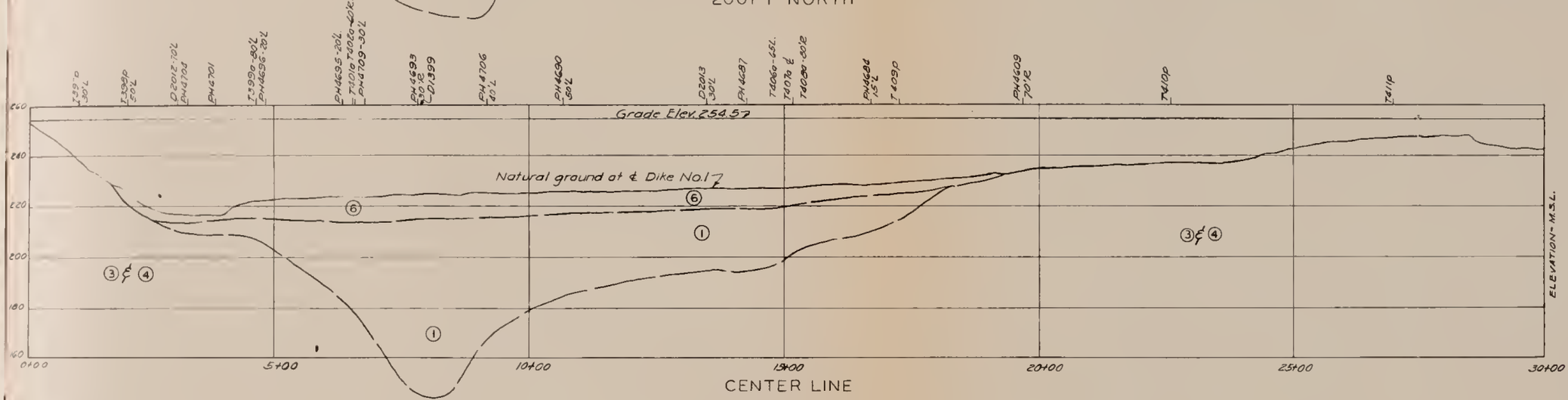
SL-5.00



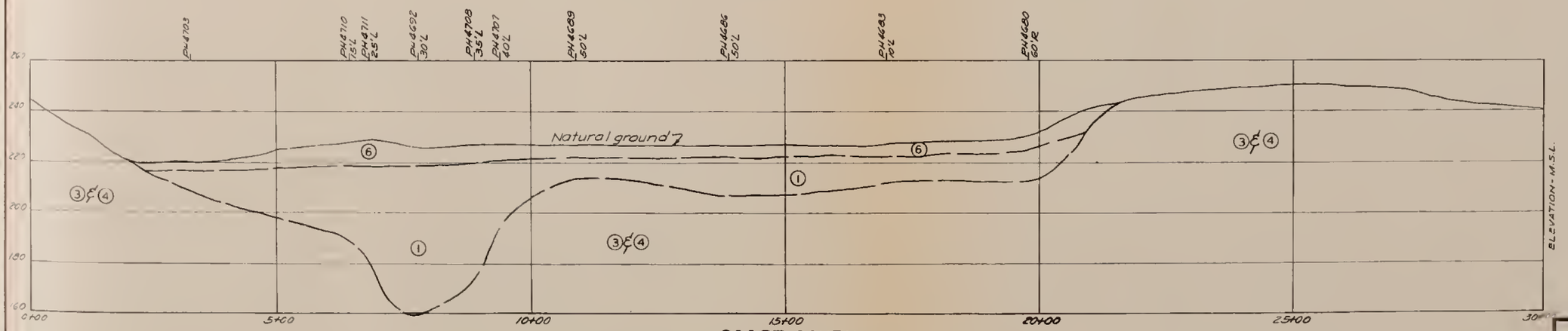
FILE NO. MC-A-2/78 PLATE IV-11



200FT NORTH



CENTER LINE



200FT. SOUTH

LEGEND:

① Soft, grey, cloy.
② Variable, sandy clay
③ Compact, clayey or silty, gravelly sand Scattered boulders.
④ Fairly compact, variable, silty gravelly sand. Scattered boulders.
⑤ Loose, variable, silty and gravelly sand.
⑥ Uniform, silty, fine to medium sand.
⑦ Stratified sand
⑧ Variable sand and gravel
—?— Boundary uncertain because of insufficient data.

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

GEOLOGICAL PROFILE
DIKE NO. 1
STA. 0+00 TO STA. 30+00

IN SHEETS | SHEET NO. | SCALE AS SHOWN

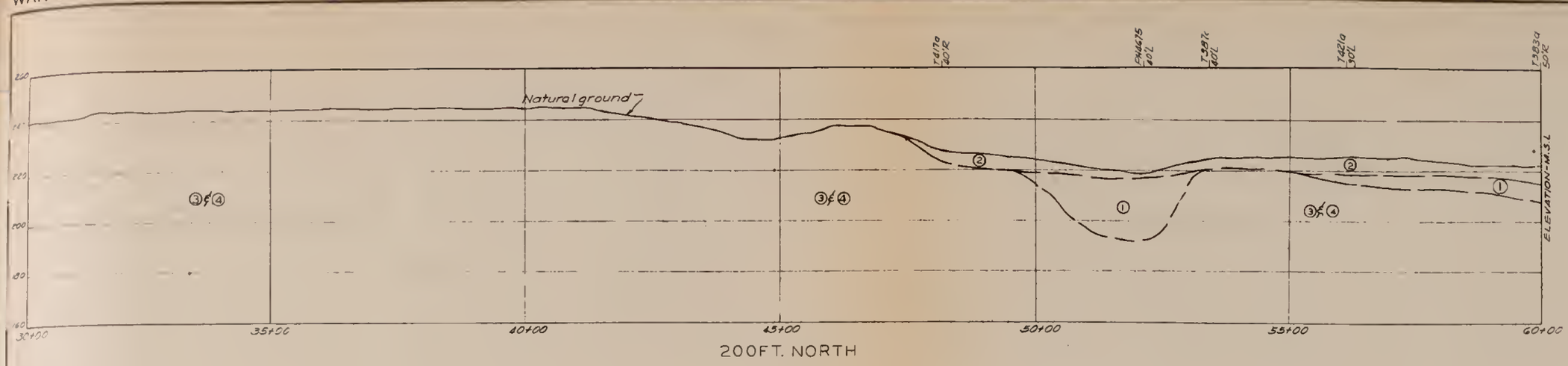
VERTICAL 20 10 0 20' 40' 100' HORIZONTAL 50 0 100' 200'

U. S. ENGINEER OFFICE, MASSENA, NEW YORK JAN. 30 1942

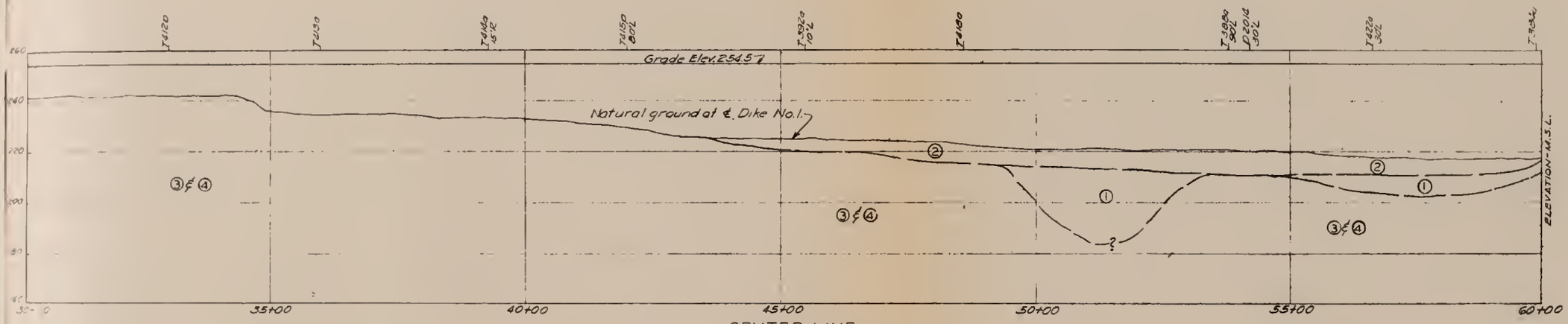
SUBMITTED: R. M. Harris, ENGINEER
RECOMMENDED: D. Sutton, LT. COL. CORPS OF ENGINEERS
APPROVED: [illegible], COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY:
CHECKED BY:
FILE NO. MC-A-2/79
TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 1941

PLATE-V-1



200 FT. NORTH



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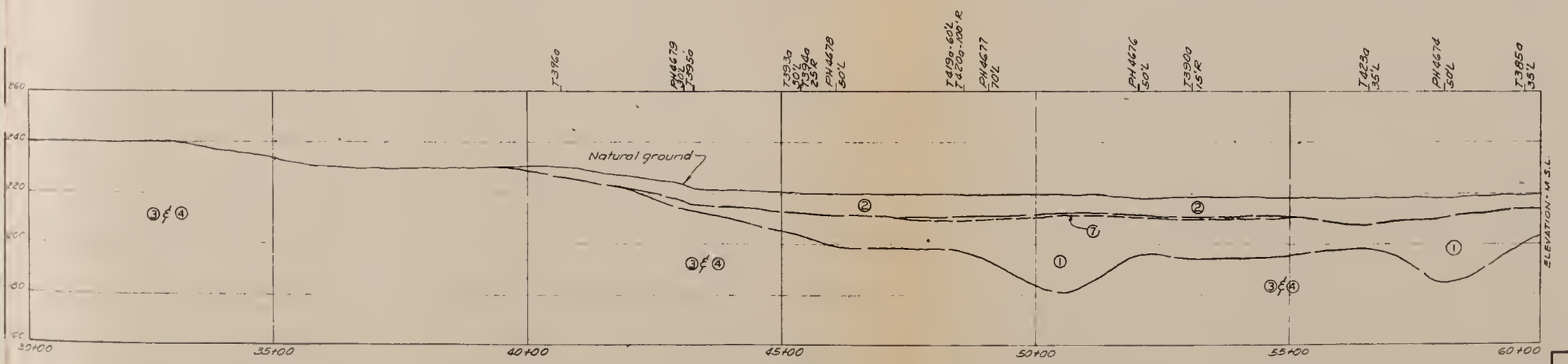


200 FT. SOUTH

LEGEND :

1. Soft, grey, clay
2. Variable, sandy clay
3. Compact, clayey or silty, gravelly sand Scattered boulders.
4. Fairly compact, variable, silty, gravelly, sand Scattered boulders.
5. Loose, variable, silty and gravelly sand.
6. Uniform, silty, fine to medium sand.
7. Stratified sand
8. Variable, sand and gravel.

—?— Boundary uncertain because of insufficient data.

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

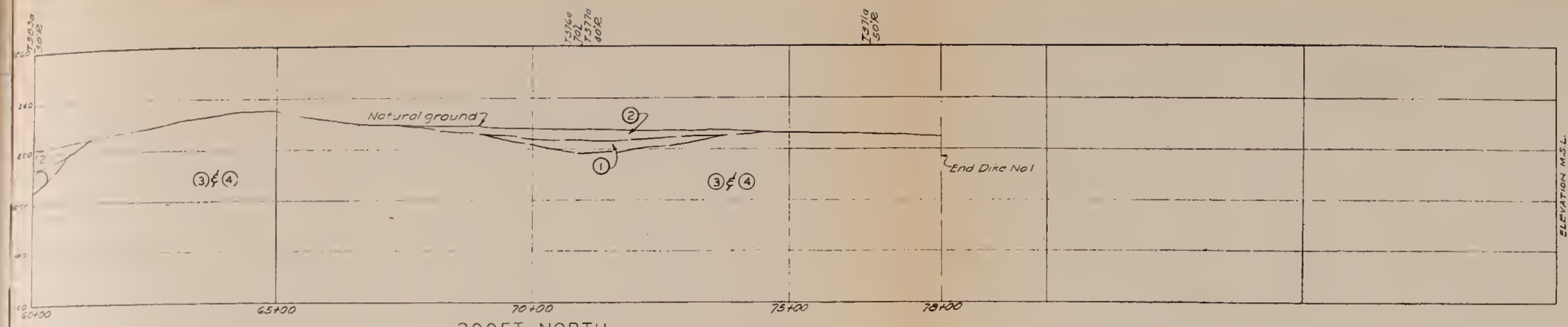
GEOLOGICAL PROFILE
DIKE NO 1
STA. 30+00 TO STA 60+00

IN SHEETS | SHEET NO | SCALE AS SHOWN
VERTICAL | HORIZONTAL

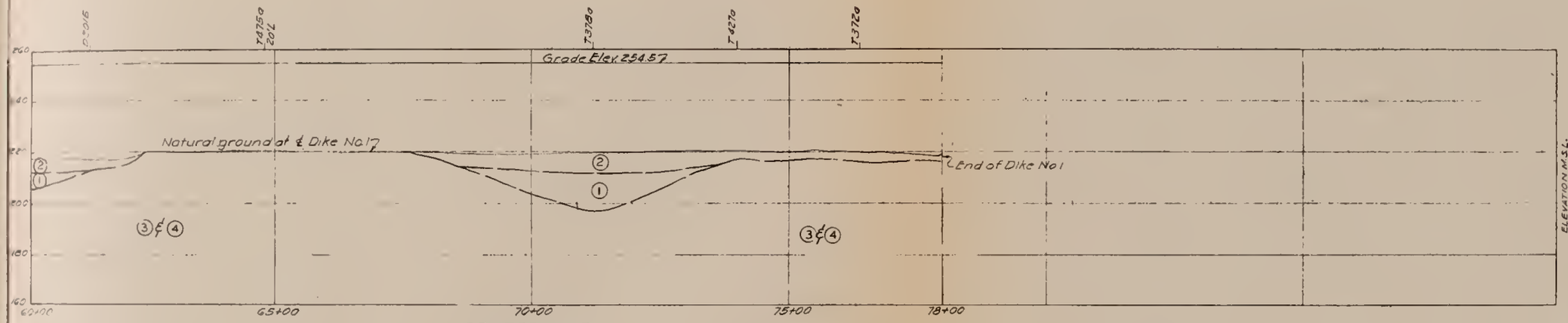
U S ENGINEER OFFICE, MASSENA, NEW YORK, JAN 30 1942

SUBMITTED: R.M. Hamer, ENGINEER
RECOMMENDED: [illegible], HEAD D&C; E.T. Sullivan, LT. COL. CE, ENGINEER
APPROVED: [illegible], DISTRICT ENGINEER
DRAWN BY | CHECKED BY GRB | FILE NO. MC-A 2/80 | DATED 1941

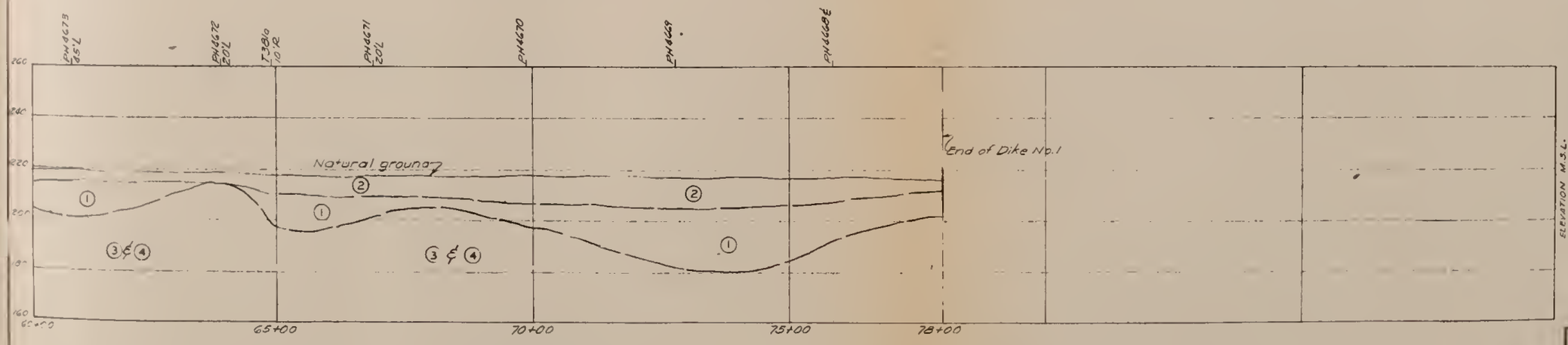
PLATE-V-2



200FT NORTH



CENTER LINE



200FT. SOUTH

LEGEND:

① Soft, grey clay.
② Variable, sandy clay
③ Compact, clayey or silty, gravelly sand. Scattered boulders.
④ Fairly compact variable silty, gravelly sand Scattered boulders.
⑤ Loose, variable, silty and gravelly sand
⑥ Uniform, silty, fine to medium sand.
⑦ Stratified sand
⑧ Variable sand and gravel.
—?— Boundary uncertain because of insufficient data.

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
GEOLOGICAL PROFILE
DIKE NO 1
STA 60+00 TO STA 78+00

IN SHEETS SHEET NO SCALE AS SHOWN
VERTICAL 20 10 0 20 40 HORIZONTAL 0 50 100 150

U S ENGINEER OFFICE, MASSENA, NEW YORK, JAN 30, 1942

SUBMITTED: R. M. Hanna, ENGINEER
RECOMMENDED: [signature], LT. COL. CORPS OF ENGINEERS
APPROVED: [signature], DISTRICT ENGINEER
DRAWN BY
CHECKED BY L.F.S.
FILE NO MC-A 2 c 2
TRANSMITTED WITH LETTER OR ENDORSEMENT

PLATE -V-3

MECHANICAL ANALYSIS

SIEVE ANALYSIS — HYDROMETER ANALYSIS

SIZE OPENING IN INCHES — NO. MESH PER INCH

"A" 2 — "B" 1.03 — "C" 0.742 — "D" 0.526 — "E" 0.371

100 26 16 8 4 3 4 6 8 10 14 20 28 35 48 65 100 150 200 250

% FINER BY WEIGHT

% RETAINED

NO.	HOLE	SAMPLE NO.	DEPTH
1	D2012	3	11.0'
2	D2013	2	10.0'
3	"	3	15.0'
4	"	8	27.0'
5	D2014	3	15.0'

SITE
HOLE
DEPTH
SAMPLES
PLOTTER
DATE

LONG SAULT CANAL
TYPICAL FOUNDATION MATERIALS
DIKE NO. 1

GLACIAL TILL

BROWN SANDY CLAY

GREY CLAY

1000.0 500.0 300.0 200.0 100.0 50.0 30.0 20.0 10.0 5.0 3.0 2.0 1.0 0.5 0.3 0.2 0.1 0.05 0.03 0.02 0.01 0.005 0.003 0.002 0.001 0.0005 0.0002 0.0001

GRAIN SIZE IN MM.

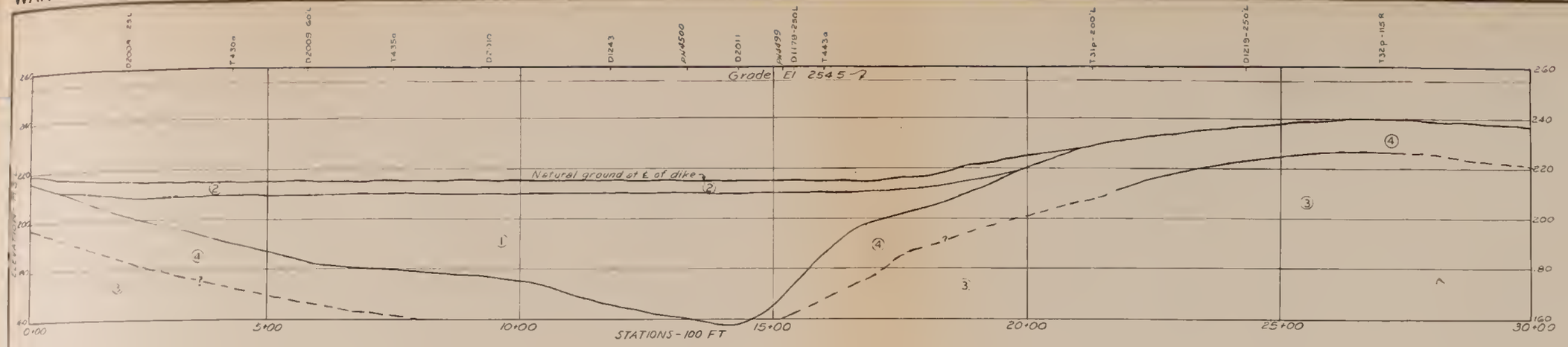
M I T SOIL CLASSIFICATION

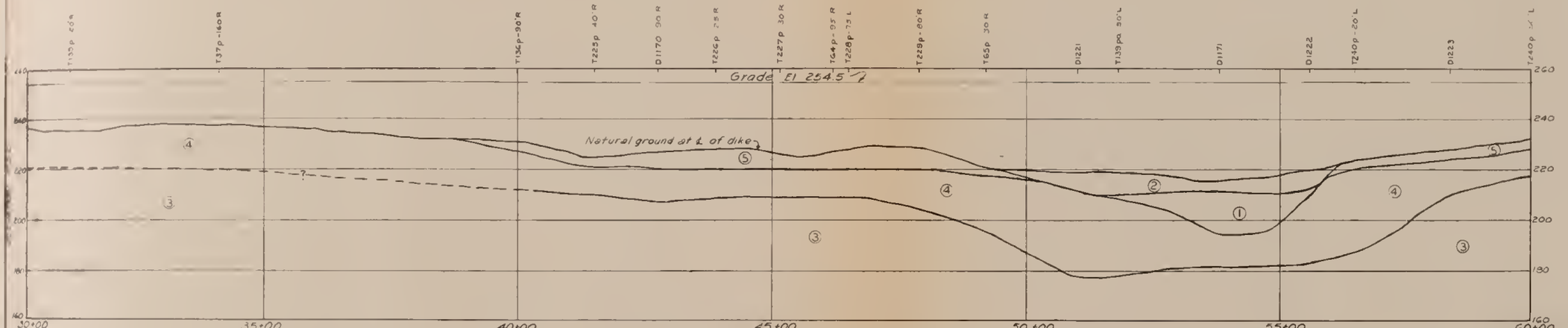
DERRICK	ONE MAN	SMALL	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	COLLOIDAL
STONE*			GRAVEL*			SAND			SILT			CLAY		

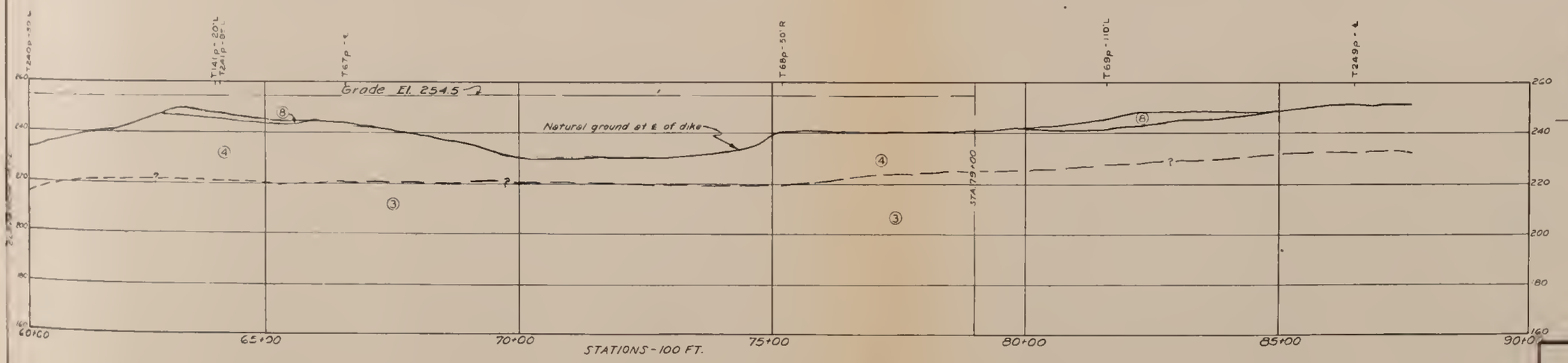
* These sizes not included in original M.I.T. Classification

FILE NO. MC-A-2/83 PLATE V-4

SL-5 00







LEGEND

① Soft grey clay
② Variable sandy clay
③ Compact, clayey or silty, gravelly sand Scattered boulders.
④ Fairly compact, variable silty, gravelly sand. Scattered boulders.
⑤ Loose, variable silty and gravelly sand
⑥ Uniform silty, fine to medium sand.
⑦ Stratified sand
⑧ Variable sand and gravel.
—?— Boundary uncertain because of insufficient data

SCALE 1"=100' HORIZONTAL
1"=30' VERTICAL

GRAPHIC SCALE VERT. 0 10 20 40 60
HORIZ 0 50 100 200 300
FEET

ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
GEOLOGICAL PROFILE
DIKE NO. 3

IN SHEETS | SHEET NO | SCALE AS SHOWN

U. S. ENGINEER OFFICE, MASSENA, NEW YORK, FEB, 1942

SUBMITTED: R. M. Hamer, ENGINEER
RECOMMENDED: [signature], HEAD ENGR
APPROVED: [signature], COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
DRAWN BY:
CHECKED BY: G.P.S.
FILE NO. MC-A-2164
TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 1941

PLATE-VI-1

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

TILL CONTOUR MAP

DIKE NO. 3

STA. 0+00 TO 19+50

U.S. ENGINEER OFFICE,
MASSENA N.Y.

JANUARY 24, 1942 SCALE: 1"=200'

FILE NO. MC-A-2/85

PLATE NO VI-2

MECHANICAL ANALYSIS

SIEVE ANALYSIS — HYDROMETER ANALYSIS

SIZE OPENING IN INCHES — NO. MESH PER INCH

100	28	16	8	4	"A" 2	"B" 1.03	"C" 0.742	"D" 0.526	"E" 0.371	3	4	6	8	10	14	20	28	35	48	65	100	150	200	250

% FINER BY WEIGHT

% RETAINED

NO.	HOLE	SAMPLE NO.	DEPTH
1	D 1171	1	6.0'
2	D 1179	3	17.5'
3	"	5	28.7'
4	"	7	38.2'
5	"	13	43.6'
6	D 1222	1	5.0'

SITE .....
HOLE .....
DEPTH .....
SAMPLES .....
PLOTTER .....
DATE .....

LONG SAULT CANAL
TYPICAL FOUNDATION MATERIALS
DIKE NO. 3

GLACIAL TILL

BROWN SANDY CLAY

GRAY SILTY CLAY

1000.0 500.0 300.0 200.0 100.0 50.0 30.0 20.0 10.0 5.0 3.0 2.0 1.0 0.5 0.3 0.2 0.1 0.05 0.03 0.02 0.01 0.005 0.003 0.002 0.001 0.0005 0.0002 0.0001

GRAIN SIZE IN MM.

M I T SOIL CLASSIFICATION

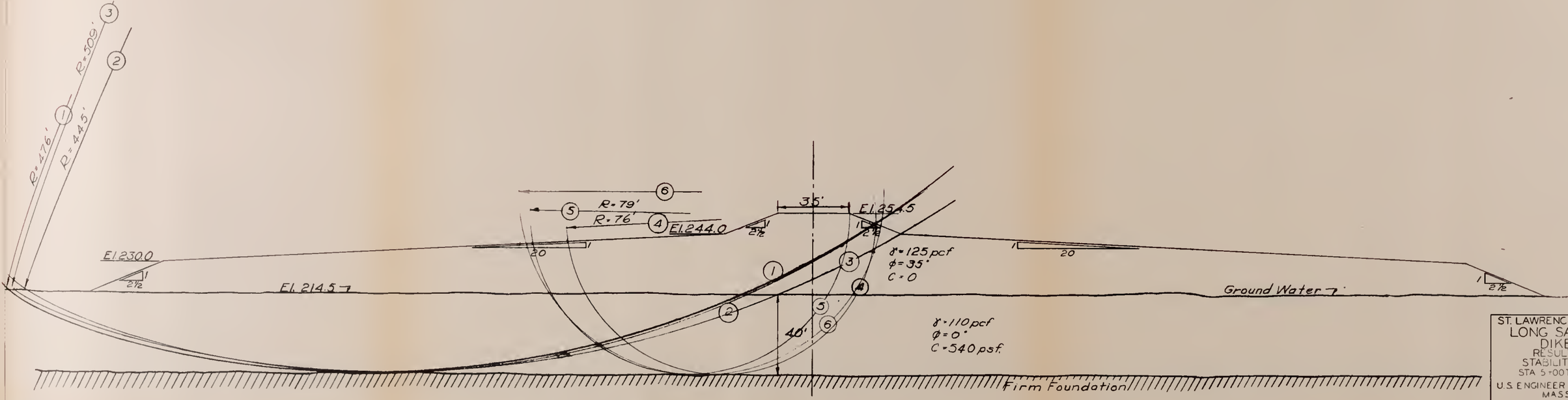
DERRICK	ONE MAN	SMALL	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	COLLOIDAL
STONE*			GRAVEL*			SAND			SILT			CLAY		

* These sizes not included in original M.I.T. Classification

FILE NO. MC-A-2/86 PLATE VI-3

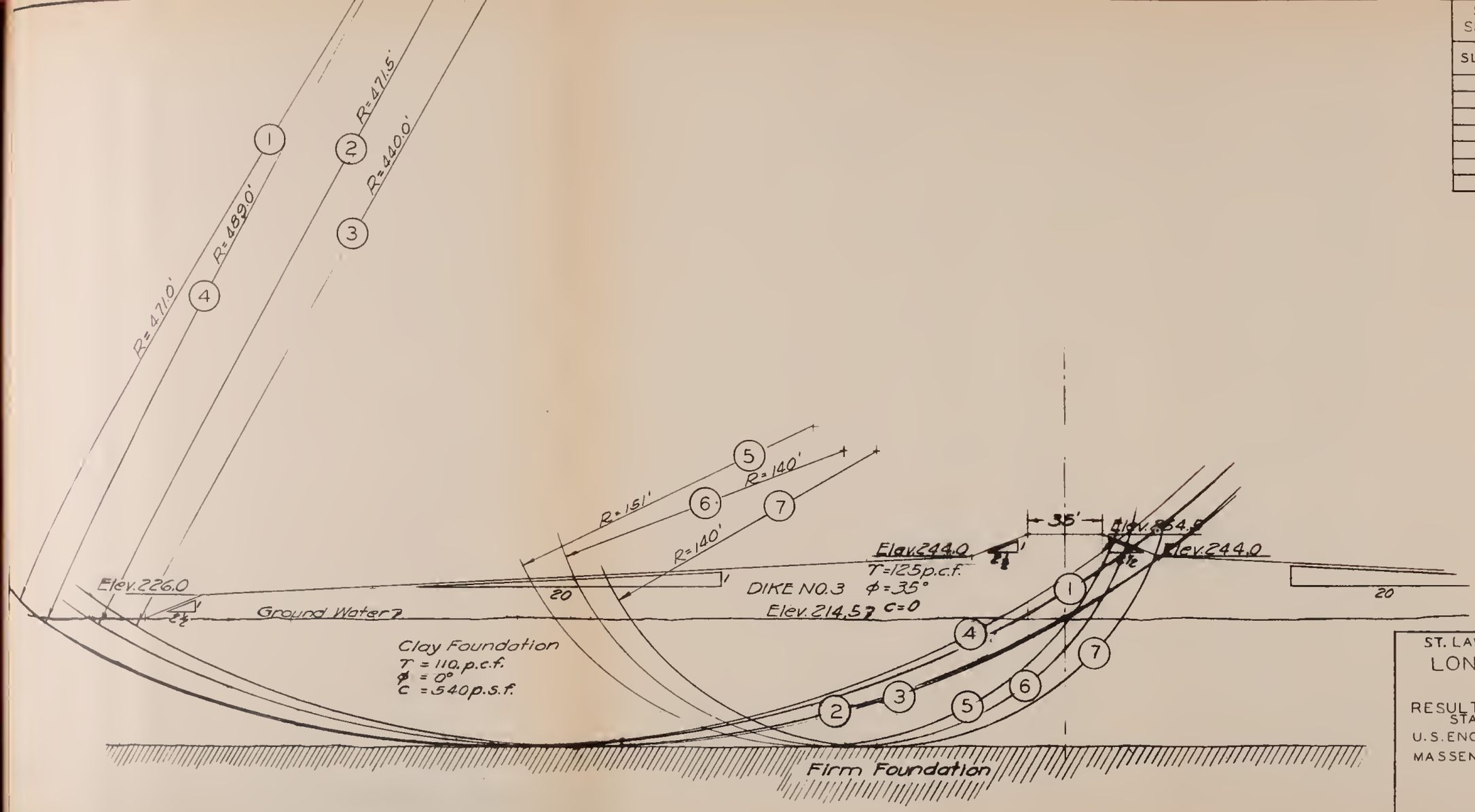
SL-5.00

STABILITY RATIOS FOR SLIDING SURFACES SHOWN	
SLIDING SURFACE	STABILITY RATIO
1	1.76
2	1.81
3	1.84
4	1.68
5	1.81
6	1.87



ST. LAWRENCE RIVER PROJECT
LONG SAULT CANAL
DIKE NO. 3
RESULTS OF
STABILITY ANALYSIS
STA 5+00 TO STA 11+00
U.S. ENGINEER OFFICE JAN. 1942
MASSENA, N.Y.
30' 0 30'

FILE NO. MC-A-2/87
PLATE VI-4



STABILITY RATIOS FOR SLIDING SURFACES SHOWN	
SLIDING SURFACE	STABILITY RATIO
1	1.67
2	1.51
3	1.64
4	1.53
5	1.64
6	1.59
7	1.71

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

DIKE NO. 3

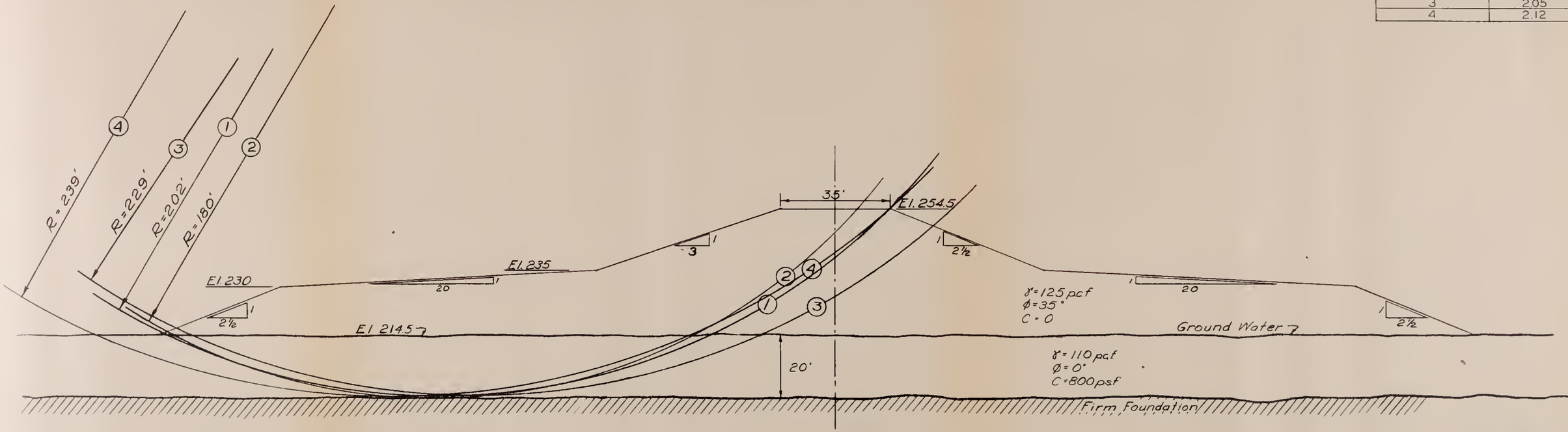
RESULTS OF STABILITY ANALYSIS
STA 11+00 TO STA. 16+50

U.S. ENGINEER OFFICE
MASSENA, NEW YORK
JANUARY 27, 1942

SCALE: 1" = 40'

FILE NO. MC-A-2/88
PLATE VI-5.

STABILITY RATIOS FOR SLIDING SURFACES SHOWN	
SLIDING SURFACE	STABILITY RATIO
1	2.04
2	2.04
3	2.05
4	2.12



ST LAWRENCE RIVER PROJECT
LONG SAULT CANAL
DIKE NO 3
RESULT OF STABILITY ANALYSIS
STA 50+00 TO STA 56+50
U.S. ENGINEER OFFICE
MASSENA, N.Y.

10' 0 10' 20'

FILE NO. MC-A-2/89 PLATE VI-6

	EMBANKMENT UNIT WEIGHT (WET) = 0.125 KIPS/CU.FT. VOLUME	γ	WEIGHT	VOLUME	γ	WEIGHT	VOLUME	γ	WEIGHT	VOLUME	γ	WEIGHT	VOLUME	γ	WEIGHT	HYDROSTATIC UPLIFT $\frac{1}{2}(h_1+h_2)\Sigma$ E_U	γ	PRESSURE	LATERAL HYDROSTATIC PRESSURES $\frac{1}{2}(h_1)^2$ E_A	γ	PRESSURE	$\frac{1}{2}(h_2)^2$ E_B	γ	PRESSURE	$E_L - E_a$	Ø DEGREES	TAN Ø	N	N TAN Ø	TANGENTIALS +T	-T	ΣT	C	L	cL
1	11.3 x 29.6 x ½ = 167.2	.125	20.9																						35	0.700	9.1	6.4	18.6			0			
2	(29.6+40) x ½ x 6.6 = 229.7		28.7																						35	0.700	15.5	10.8	24.3			0.54 KIPS/SQ.FT.		
3	40 x 28.4 = 1136.0		142.0																										102.1			0.54 "		"
4	(40+29.5) x ½ x 26.2 = 910.4		113.8																										80.7			0.54 "		"
5	(29.5+20.7) x ½ x 174.8 = 4387.5		549.0																											87.2		0.54 "		"
6	20.7 x 11.7 x ½ = 121.1		15.1																						35	0.700	8.1	5.7		12.8		0		
7																																		
8																																		
9																																		
10																																		
11																																		
12																											32.7	22.9	205.7	100.0	105.7		268.5	145.0

FORCES RESISTING			DRIVING	STABILITY RATIO
$\Sigma N \cdot \tan\phi$	$c\hat{L}$	TOTAL	ΣT	$\frac{\Sigma N \cdot \tan\phi + \hat{L} \cdot c}{\Sigma T}$
22.9	145.0	167.9	105.7	1.59

COHESION

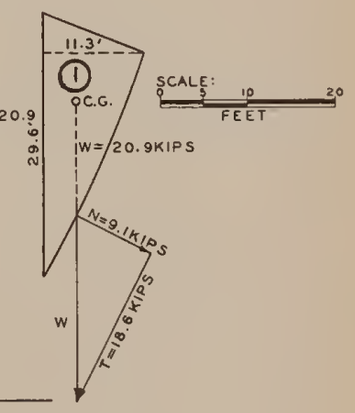
$\hat{L} = 140 \times \pi \times \frac{110°}{180°} = 268.5'$ = LENGTH OF ARC

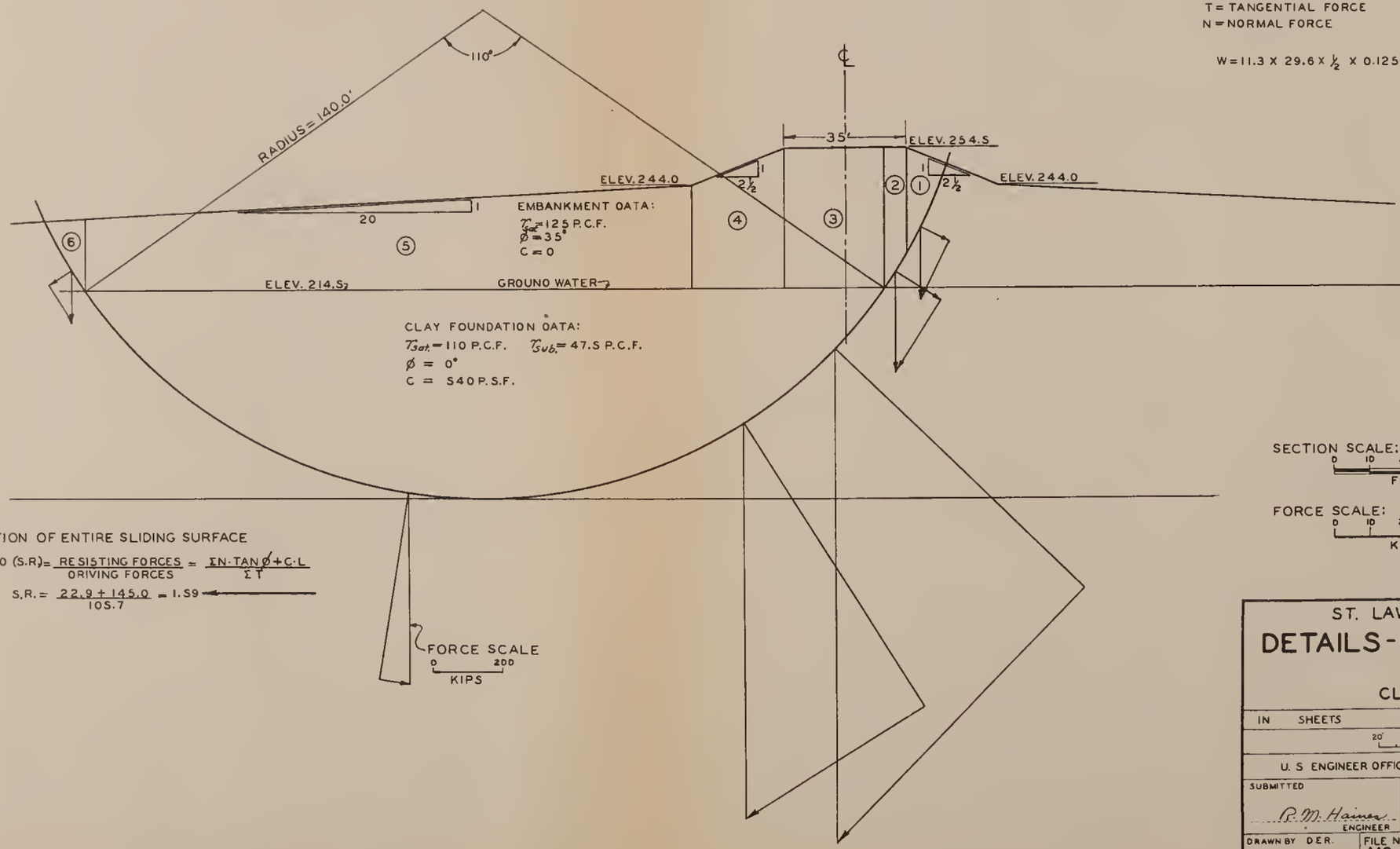
$c \cdot \hat{L} = 0.540 \times 268.5 = 145.0$ KIPS = TOTAL COHESION

GRAPHICAL DETERMINATION OF SLICE NO.1

W = WEIGHT OF SLICE
T = TANGENTIAL FORCE
N = NORMAL FORCE

$W = 11.3 \times 29.6 \times \frac{1}{2} \times 0.125 = 20.9$





SUMMATION OF ENTIRE SLIDING SURFACE

STABILITY RATIO (S.R.) = $\frac{\text{RESISTING FORCES}}{\text{DRIVING FORCES}} = \frac{\Sigma N \cdot \tan\phi + C \cdot L}{\Sigma T}$

$S.R. = \frac{22.9 + 145.0}{105.7} = 1.59$

SECTION SCALE:
0 10 20 40
FEET

FORCE SCALE:
0 10 20 40
KIPS

ST. LAWRENCE RIVER PROJECT

DETAILS - STABILITY ANALYSIS
DIKE NO. 3
CLAY FOUNDATION

IN SHEETS | SHEET NO. | SCALE: AS SHOWN
20' 0 20' 40'

U. S ENGINEER OFFICE. MASSENA, NEW YORK JANUARY 28, 1942

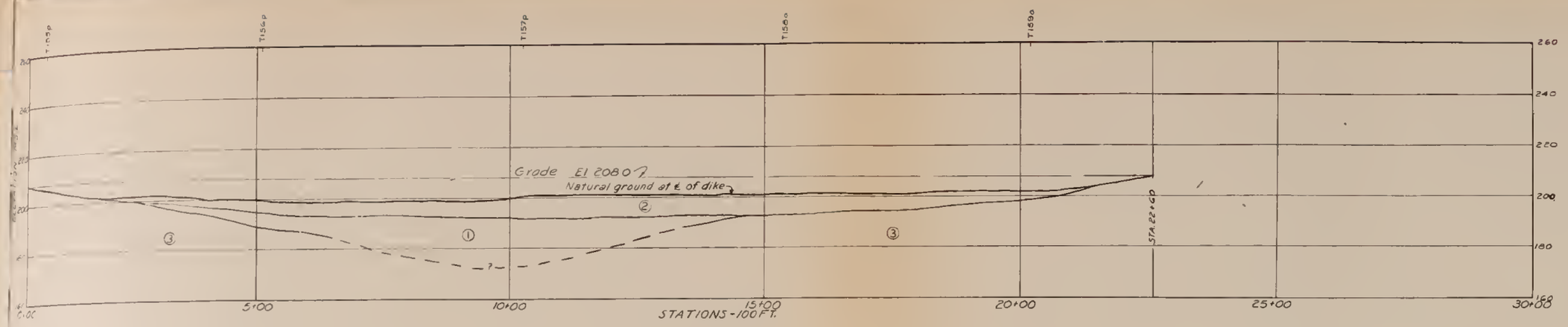
SUBMITTED: R. M. Haines, ENGINEER
RECOMMENDED: J. T. Rather, MEA/ENGR; E. Bullard, LT COL. CORPS OF ENGINEERS
APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY D.E.R.
CHECKED BY C.F.P.
FILE NO MC-A-2/90
TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 1941

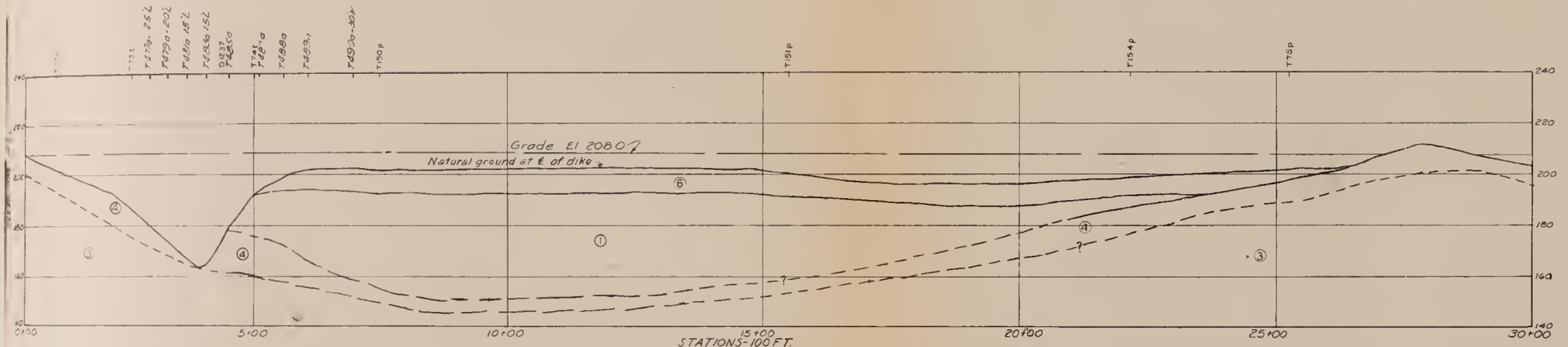
PLATE VI-7

WAR DEPARTMENT

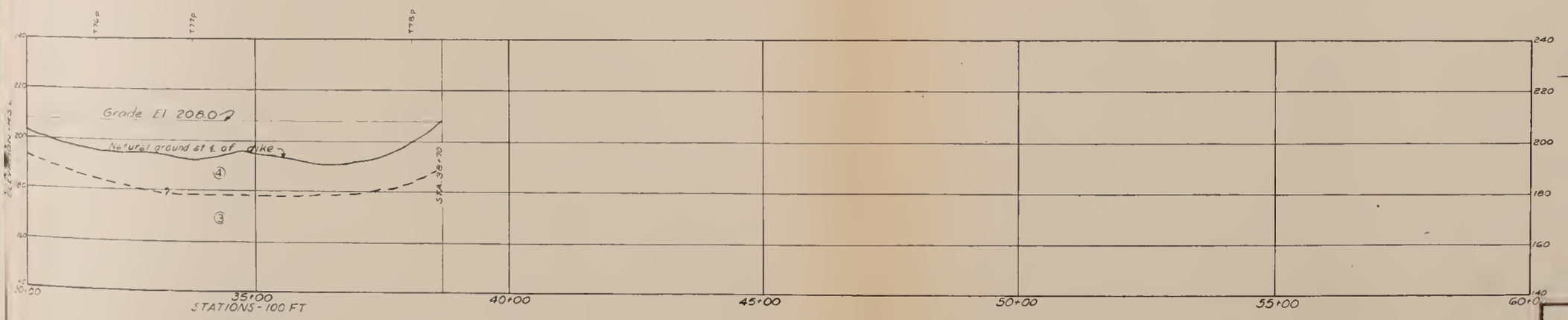
CORPS OF ENGINEERS, U. S. ARMY



DIKE NO. 5



DIKE NO 6



DIKE NO 6

LEGEND:

1. Soft, gray, clay
2. Variable sandy clay
3. Compact, clayey or silty, gravelly sand. Scattered boulders.
4. Fairly compact, variable, silty gravelly sand. Scattered boulders
5. Loose, variable, silty and gravelly sand.
6. Uniform, silty, fine to medium sand.
7. Stratified sand.
8. Variable sand and gravel

—?— Boundary uncertain because of insufficient data.

SCALE: 1"=100' HORIZONTAL
1"=30' VERTICAL

GRAPHIC SCALE VERT. 0 10 20 40 60
HORIZ. 0 50 100 200 300
FEET

ST. LAWRENCE RIVER PROJECT

LONG SAULT CANAL

GEOLOGICAL PROFILE
DIKES NOS. 5 AND 6

IN SHEETS	SHEET NO.	SCALE AS SHOWN

U. S. ENGINEER OFFICE, MASSENA, NEW YORK. FEB. 1942

SUBMITTED:	RECOMMENDED:	APPROVED:
R. M. Haines, ENGINEER	D. Sullato, LT. COL. CORPS OF ENGINEERS	COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY:	FILE NO.	TRANSMITTED WITH LETTER OR ENDORSEMENT
CHECKED BY: G.E.S.	MG-A-2/91	DATED 1941

PLATE-VII-1

MECHANICAL ANALYSIS

SIEVE ANALYSIS — HYDROMETER ANALYSIS

SIZE OPENING IN INCHES — NO. MESH PER INCH

"A" 2 — "B" 1.03 — "C" 0.742 — "D" 0.526 — "E" 0.371

28 16 8 4 3 4 6 8 10 14 20 28 35 48 65 100 150 200 250

% FINER BY WEIGHT

100 90 80 70 60 50 40 30 20 10 0

0 10 20 30 40 50 60 70 80 90 100

SITE ....
HOLE ....
DEPTH ....
SAMPLES ....
PLOTTER ....
DATE ....

LONG SAULT CANAL
TYPICAL FOUNDATION MATERIALS
DIKE NO. 5

NO.	HOLE	SAMPLE NO.	DEPTH
1	T85p	2	4.5'
2	T89p	1	5.0'
3	T89p	2	10.5'
4	T90p	1	5.0'

GLACIAL TILL

CLAY

% RETAINED

1000.0 500.0 300.0 200.0 100.0 50.0 30.0 20.0 10.0 5.0 3.0 2.0 1.0 0.5 0.3 0.2 0.1 0.05 0.03 0.02 0.01 0.005 0.003 0.002 0.001 0.0005 0.0002 0.0001

GRAIN SIZE IN MM.

M I T SOIL CLASSIFICATION

DERRICK	ONE MAN	SMALL	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	COLLOIDAL
STONE*			GRAVEL*			SAND			SILT			CLAY		

* These sizes not included in original M.I.T. Classification

FILE NO. MC-A-2/92 PLATE VII-2

SL-5.00

MECHANICAL ANALYSIS

SIEVE ANALYSIS — HYDROMETER ANALYSIS

SIZE OPENING IN INCHES — NO. MESH PER INCH

"A" 2 | "B" 1.03 | "C" 0.742 | "D" 0.528 | "E" 0.371

100 28 16 8 4 3 4 6 8 10 14 20 28 35 48 85 100 150 200 250 0

% FINER BY WEIGHT

% RETAINED

NO.	HOLE	SAMPLE NO.	DEPTH
1	D1237	1	6.0'
2	D1237	3	18.0'
3	T151p	2	7.0'
4	T151p	5	15.0'

SITE.....
HOLE.....
DEPTH.....
SAMPLES.....
PLOTTER.....
DATE.....

LONG SAULT CANAL

TYPICAL FOUNDATION MATERIALS

DIKE NO. 6

GLACIAL TILL

CLAY

1000.0 500.0 300 0 200 0 100.0 50.0 30 0 20.0 10 0 5.0 3.0 2.0 1.0 0.5 0 3 0.2 0.1 0.05 0.03 0.02 0.01 0.005 0 003 0.002 0 001 0.0005 0 0002 0.0001

GRAIN SIZE IN MM.

M I T SOIL CLASSIFICATION

DERRICK	ONE MAN	SMALL	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	COLLOIDAL
STONE*			GRAVEL*			SAND			SILT			CLAY		

* These sizes not included in original M.I.T. Classification

FILE NO. MC-A-2/93 PLATE VII-3

LONG SAULT CANAL

ANALYSIS OF DESIGN

APPENDIX A

An investigation was made of the methods and experience during construction at the Beauharnois Canal and hydroelectric development on the St. Lawrence River to make a comparison of the clays in that area with those deposited in the area of the St. Lawrence River Project. Much information was obtained and it is presented in the following report. Later during the investigations for the dikes in the vicinity of the Long Sault Canal two 6" holes were drilled to obtain undisturbed samples from the Beauharnois area. The samples were tested for shearing strength, water content, specific gravity, and Atterburg Limits so that the results could be compared with those obtained on undisturbed samples taken from the Long Sault Canal area. The sampling operation and testing procedures were similar to those described in the Long Sault Canal Design Analysis. The results of the tests have been appended to the following report as Plates A-1 to A-7. The location of the two drill holes have been inserted on Figure 1 of the basic report. Detailed descriptions of the tests are presented in the Final Report prepared by the Syracuse District Soils Laboratory, on file in the district office files.

INVESTIGATIONS AT BEAUHARNOIS CANAL

I. INTRODUCTION

1. Purpose. - The purpose of the investigations at Beauharnois Canal was to study methods and experiences during construction of the canal to obtain information that would possibly be useful to the U. S. Engineer Office at Massena, N. Y. in the design and construction of the canal slopes and dikes in connection with the St. Lawrence River Project. Records of subsurface exploration, soil test data, and reports and plans of the progress of construction were made available to the writer by the Beauharnois Light, Heat, and Power Company which was formerly the Beauharnois Construction Company, during early construction stages. Descriptions of the project are based on data furnished by the power company, and details of construction operations and information on difficulties encountered during construction are based on interviews with company officials.

II. SUMMARY

2. General. - Construction of Beauharnois Canal involved the construction of approximately 30 miles of dikes along the canal varying in height from 10 to 45 feet, and necessitated diversion of three railway roadbeds which required embarkment fills up to 30 feet in height. These dikes and embankments were founded on marine clay which had a relatively low bearing capacity and extended to a maximum depth of 45 feet. In some areas during construction the canal dikes slumped at a height of about 24 feet with slopes of 1 on 3, and the railroad embankment slumped at heights of 20 to 25 feet with slopes of 1 on 1-1/2. In the same areas dikes and embankments of similar height and slopes stood up without any indications of slumping. An analysis has been made of these conditions from the available information, and the conclusions have been reached that where foundation conditions were not a deciding factor, some minor variation in construction procedure was sufficient for some sections to be stable and others to slump.

III. GENERAL DESCRIPTION

3. Site. - The Beauharnois hydroelectric development site, shown in Fig. 1, is located in the Province of Quebec between Lake St. Francis and Lake St. Louis. Between the two lakes the St. Lawrence River has a drop of approximately 83 feet in 15 miles. The development which is to be an integral part of the proposed St. Lawrence Waterway consists of a diversion canal between the two lakes located south of the St. Lawrence River with the power plant at the Lake St. Louis end near the town of Beauharnois which is located 25 miles from Montreal. The Beauharnois Canal project was started in 1929, and when completed the development will have a generating capacity of approximately 2,000,000 hp. Provision has been made for a navigation channel in the power canal, and the Canadian Government has reserved the right to construct the necessary locks between the canal and Lake St. Louis. Included in the development are plans for constructing river control works in the St. Lawrence River which consist of dams across three of the four river channels at the head of various rapids between the two lakes to regulate flow and to maintain the level of Lake St. Francis. This part of the development has been in

progress since 1933.

4. Construction Program. - The canal which is 15.5 miles long extends across relatively flat country, and practically the entire canal area is below the Lake St. Francis low water level, so that it was necessary to carry the canal between dikes for its entire length. The construction procedure consisted of building dikes from the surface material in the canal area and dredging from the canal when the dikes were completed depositing the material behind the dikes. The design and construction of the project was based on step by step construction. As the need for additional water diversion has increased, additional excavation by dredging has been carried on, and this procedure will be followed to the completion of the development. The development also involved the maintenance across the canal of three railways and two main highways carried on bridges. Construction of railway approach fills was carried on simultaneously with construction of the canal dikes.

5. Subsurface Exploration. - The overburden in the canal area was explored by the construction company by test pits and sounding using rod and casing to determine the extent of marine clay and the depth to sand and gravel. A plan of the exploration with descriptions of materials encountered is shown in Figs. 2 and 3. In the progress of investigations for the Massena Office, exploration by auger borings and soundings was made to obtain additional information concerning subsurface conditions along the south approach to the Canadian National Railway bridge.

6. Subsurface Formations. - In general, the soil through which the canal was cut has a relatively low bearing capacity and consists of a layer of brown clay for the most part overlying marine clay. The bearing capacity of this soil was insufficient in many instances to support the loads imposed by the construction of canal dikes and railroad embankments and slumping occured during construction. At the Lake St. Francis end of the canal the ground surface is relatively low, being only slightly above the normal lake level. Over most of the canal route the ground surface is level, but about 4 miles east of Lake St. Francis a glacial boulder clay ridge occurs about 10 feet above lake level which crosses the canal. Beyond the ridge the ground surface is uniformly flat until in the vicinity of the power house forebay where it rapidly falls away to the level of Lake St. Louis.

7. In the area where construction difficulties were encountered, the overburden consists of a layer of comparatively firm brown clay varying in thickness from 2 to 6 feet underlain by soft marine clay which extends to a maximum depth of 45 feet as shown in the geologic profiles of Figs. 4 and 5. At the lower end of the canal the marine clay is very shallow or absent altogether. Glacial sand, gravel, and boulder clay underlay the clay over the entire area. Rock which underlies the sand and gravel is Potsdam sandstone at the Lake St. Louis end and limestone at the upper end.

8. Test Data. - Soil tests were conducted during initial stages of construction to determine the characteristics of the overburden materials. Mechanical analyses were made to determine grain size distribution and colloidal content, and other tests consisted of specific gravity, water content, and unit weight determinations. Loading tests were conducted to obtain information regarding the bearing capacity of the clay. Specific gravity determinations of solid particles of marine clay gave results varying from 2.75 to 2.80. Test results indicated that the water content varied from 60 to 100% by dry weight with an average of about 90% (50% of total weight).

9. Photographs. - Photographs were made of the canal dikes and railway embankments immediately after slumping and are on file in the office of the Beauharnois Light, Heat, and Power Company. Reference to typical photographs is given in Table I.

IV. DIKES

10. General Plan and Design. - The dikes along the canal were built to provide a minimum channel width of 3380 feet crest to crest of dikes which will ultimately accommodate a floor equal to the full allotted diversion from Lake St. Francis at low stage. At the upper end of the canal the dikes are low and gradually increase to a maximum height of 45 feet at the power house forebay. The general plan of construction consisted of building the canal dikes in three parts, two parallel outer embankments and a central core of dredge fill or puddle core.

11. The canal was designed for a maximum water velocity of 2.25 feet per second. However, the final dimensions, limits of excavation, and side slopes have been determined on the basis of material encountered as the work progresses. When completed the navigation channel will have a minimum depth of 27 foot over a clear bottom width of 600 feet. It follows the live of the north dike, and for this reason all dredgings has been done at that side of the canal.

12. Construction. - Due to the low bearing capacity of the soil, the main north and south dikes were constructed in three separate stages. The first stage consisted of building dikes having a top width of 10 feet and 1 on 5 slopes on the canal side and any slope the material would take on the land side. The next step was to erect a parallel dike 5 feet wide on top at a minimum distance of 200 feet on the land side of the canal dikes having any side slopes the material would take. The two parallel dikes were built of surface soil dragged into place by tower excavators or draglines. The surface soil consisting of brown clay was used because of its more stable character than the underlying marine clay. When the two embankments were completed the final step consisted in digging a cut-off trench between the two dikes and filling the area with subsurface clay dredged from the canal. The distance between the inner embankment, which lies along the canal and is called the "A" dike, and the outer or secondary embankment called the "B" dike, has been varied from 200 to 600 feet to provide spoil areas for the excavated material. To provide additional spoil areas and stilling basins, auxiliary dikes were placed in back of the "B" dikes. A general plan of these dikes and stilling basins is shown in Fig. 1.

13. Construction Difficulties. - Difficulties were encountered during construction of the "A" dikes along the canal from the vicinity of the Canadian National Railway to within two miles of the power house. A slump of 5 to 10 feet would occur accompanied by bulging of the ground surface immediately beyond the toe. This difficulty occurred along both sides of the canal, the slumping being prevalent along the entire reach of the north dike in this area and intermittent along the south dike. The maximum side slopes before slumping varied from 1 on 2-1/2 to 1 on 3 for heights of fill varying from 20 to 24 feet. In the same area dikes which remained stable had slopes of about 1 on 2.8 for an average height of 24 feet. As attempts were made to top off the dikes additional slumping would occur, but when finally built to grade at Elev. 160, there were no further difficulties. Of particular significance is the fact that no difficulties occurred during construction of the "B" dikes which had maximum slopes of 1 on 2.1 for an average height of 20 feet. Typical cross sections of the south dike indicating the progress of construction are

shown in Fig. 6. In general, the "A" dikes would attain a condition of equilibrium when sufficient material had been added to provide about 1 on 5 slopes. Dredging operations were not begun until the canal dikes had been completed, and at all times during dredging excavation the water level in the canal was maintained at approximately 2 feet below the original ground surface.

14. Along one section of the North dike where slumping had occurred during construction, the "A" dike slumped about two years later when the core pool was about 15 feet above the original ground surface. This occurred one month after the dredge had pumped material into this particular area. The dredge cut at this time was located approximately 450 feet from the toe of the dike. Soundings were made in the dredge cut to determine whether that region had been affected, but there were no indications of any disturbances. This is believed to be the only case where slumping occured during pumping into the core pool Typical cross sections in this area before and after slumping are shown in Fig. 7.

15. Analysis of Construction Difficulties. - There are two considerations which could possibly explain the reason for the "B" dikes to remain standing with slopes steeper than the "A" dikes which slumped, namely, a variation in construction procedure or a change in foundation conditions. The construction procedure which consisted of dumping fill material uniformly with tower excavators was apparently similar for both dikes. However, since the top elevation of the "A" dikes was ultimately to be 4 feet higher than the "B" dikes, it is possible that some minor variations in construction caused slumping by overstressing the foundation and that the "B" dikes which were at the point of incipient failure had a slightly higher factor of safety. Although the depth of marine clay varied considerably over relatively large areas, the available information on subsurface conditions gave few indications of abrupt changes, at least in the comparatively short distances between parallel dikes, and it therefore appears that the possibility of changes in the foundation can be discounted.

V. CANAL SLOPES

16. Dredging Operations. - Excavation in the canal has been chiefly in clay except for sand and gravel for approximately one mile in the area of the glacial ridge. In some areas considerable excavation will be necessary in the sand and gravel beneath the clay. Dredging operations were begun in the vicinity of the lower New York Central Railway crossing by digging a pit for the dredge and flooding it so that the dredge could work its way up the canal along the line of the navigation channel. As mentioned before, the water level during all dredging excavation prior to diversion was maintained about 2 feet below the original ground surface. No attempt has been made to trim the channel slopes by dredging, and at present the maximum slopes adjacent to the north embankment are about 1 on 1-1/2 while the opposite slopes are practically vertical for a 15 foot depth of cut. The present water level in the canal is maintained at Elev. 150.5.

VI. RAILROAD EMBANKMENT

17. General Plan. - The construction of the Canadian National Railway relocation about midway down the canal made it necessary to construct embankment fills at the north and south approaches to the bridge. Requirements of railway companies for crossing navigation bridges made long approach embankments necessary which involved construction of fills up to 30 feet above the ground surface.

18. Construction. - The construction procedure consisted of erecting trestles on wooden sills which were placed on the ground surface approximately 10 feet apart. Timber stringers were placed on the trestles, and railroad tracks were laid. Fill material consisting of glacial sand, gravel and boulder clay obtained from a pit 20 miles away, was hauled by railroad cars and dumped from the trestle. No attempt was made to compact the fill, and the embankment was built allowing the material to assume a natural slope of about 1 on 1-1/2.

19. Construction Difficulties. - Numerous slumps accompanied by rupture of the ground surface beyond the toe occurred during construction when the fill was about 20 to 25 feet above ground surface. These occurred in two areas on the north approach and on the south approach from the last bridge pier for a distance of about 3500 feet. Slump after slump occurred in these areas during construction, and before a conditon of equilibrium was established, it was necessary to place approximately 2,000,000 yards of material below the ground surface.

20. Analysis of Construction Difficulties. - The existance of a stable embankment section on the north approach between areas where slumping occurred was apparently due to the relatively shallow depth of the soft marine clay, as shown in the geologic profile of Fig. 5. Since only meager information was available concerning foundation conditions along the south approach, additional exploration by borings and soundings was made during the investigations to determine whether the marine clay decreased in depth progressing from the area where the embankment slumped to the area where no slumping occurred. However, the exploration indicated only comparatively minor changes in the depth of the clay. A possible explanation of the greater degree of stability of the embankment along the further reaches of the south approach is that a more favorable drainage condition had resulted in a higher degree of consolidation and correspondingly greater shearing strength.

21. It is to be noted that after the railway embankment was finally constructed to grade in the areas where construction difficulties were encountered, no further slumping occurred. Well drill borings were later made in this area along the south approach to determine the final thickness of marine clay. No clay was encountered at one location where the clay had originally been 40 feet deep.

22. Additional Subsurface Exploration. - The additional exploration made along the south railway approach consisted of eight auger borings and two rod soundings to determine the character and extent of the brown clay and underlying marine clay. Representative samples were obtained of the materials encountered, and water content determinations were made at the Massena laboratory. The location and results of the exploration are shown on the geologic profiles in Fig. 5. Field logs describing the materials encountered are included in this report as an appendix.

VII. CONCLUSIONS

23. Soil Conditions. - The results of the Investigations of subsurface exploration and soil test data indicate that the overburden materials have similar origin and are similar in character to those encountered at Massena with the notable exception that the marine clay at Beauharnois has a higher water content (90% as compared with 60%) which indicates a lower shearing strength.

24. General. - The results of the investigations are inconclusive because of the lack of definite information about subsurface conditions and the character of the overburden materials. The difference in the sizes and slopes of the embankments at the time of initial construction

difficulties was comparatively insignificant, and it is believed that minor variations in constuction procedure were sufficient to cause some sections to slump and others to remain stable. However, it is evident from the construction experiences at Beauharnois that unless sufficient time is allowed for the foundation to consolidate under the applied loads as construction progresses, the bearing capacity of the clay may be insufficient to support loads imposed by embankments of the manitude proposed by the Massena office. There are indications that the shearing strength of the Massena clay is greater than the clay at Beauharnois. Any added precautions, such as placing the fill at such a rate so as not to overstress the foundation material at any time or draining the clay foundation to accelerate consolidation, thereby resulting in increased shearing strength, would give an additional margin of safety against possible construction difficulties or subsequent foundation failure.

VIII. RECOMMENDATIONS

25. If it is considered sufficiently important to obtain reliable information about subsurface conditions at the Beauharnois Canal site which would explain the lack of stability of the various embankments during the initial stages of construction, it is recommended that exploration be made by drilling in various areas to obtain undisturbed samples of clay for soil testing purposes to compare with the materials at Massena.

TABLE I

CONSTRUCTION PHOTOGRAPHS

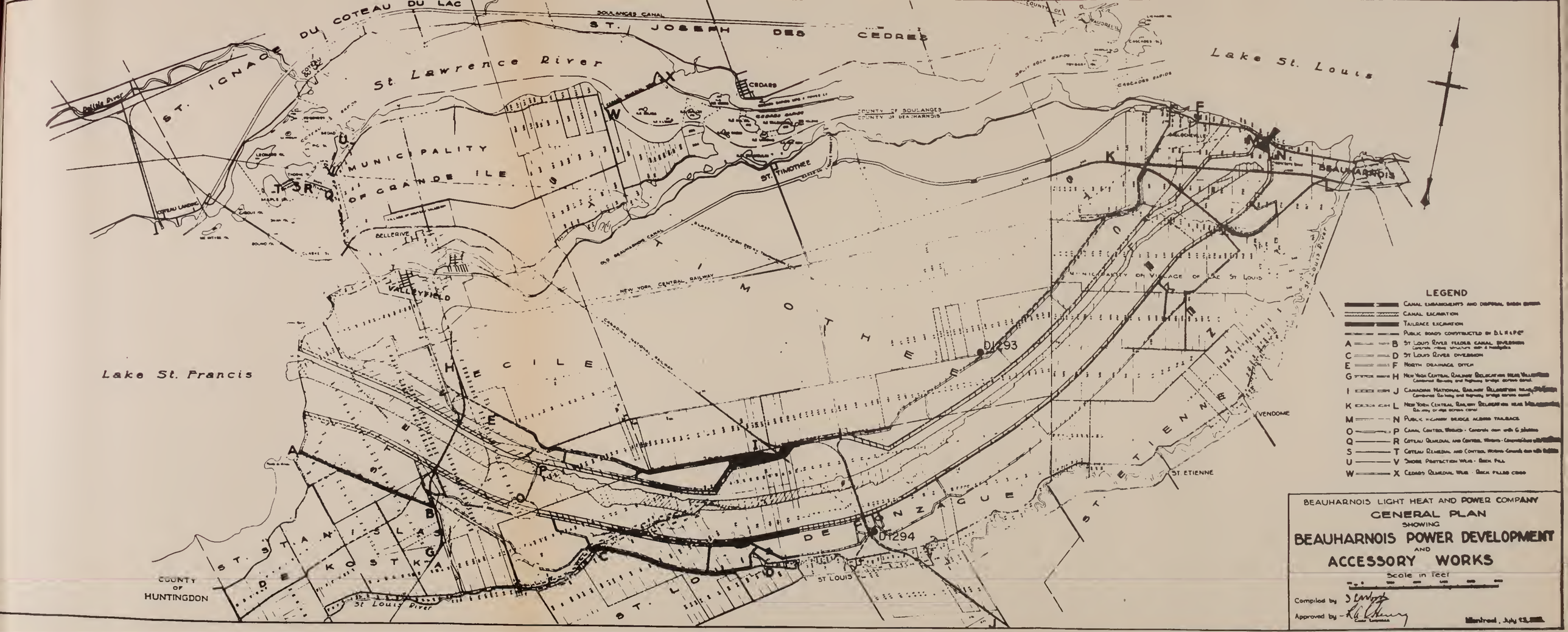
B 249-8-18-30 to B 254-8-18-30

Construction of north Canadian National Railway approach fill. Views showing ground surface buldging beyond toe of fill for approximately 100 feet from effects of a 10 foot slump.

B 1243-7-16-32 to B 1247-7-16-32

Views showing slump on the south dike at approximately Sta. 420. Railroad engine and cars on fill.

Note: Negatives and prints of the above and numerous other photographs are on file at the power plant of the Beauharnois Light, Heat, and Power Company, Beauharnois, Quebec.


ST. IGNACE DU COTEAU DU LAC
SOULANGES CANAL
ST. JOSEPH DES CEDRES
St Lawrence River
Lake St. Louis
CEDARS
COUNTY OF SOULANGES
COUNTY OF BEAUHARNOIS
ST. TIMOTHEE
MUNICIPALITY OF GRANDE ILE
BEAUHARNOIS
BELLERIVE
VALLEYFIELD
OLD BEAUHARNOIS CANAL
NEW YORK CENTRAL RAILWAY
CANADIAN NATIONAL RAILWAY
MUNICIPALITY OF VILLAGE OF LAC ST LOUIS
Lake St. Francis
D1293
D1294
VENDOME
ST ETIENNE
ST LOUIS
ST. STANISLAS DE KOSTKA
COUNTY OF HUNTINGDON
St Louis River
LEGEND
Canal embankments and disposal areas outside
Canal excavation
Tailrace excavation
Public roads constructed by B.L.H.&P.Co
A — B St Louis River feeder canal diversion
C — D St Louis River diversion
E — F North drainage ditch
G — H New York Central Railway Relocation and Beauharnois Valleyfield Canadian Railway and highway bridge across canal
I — J Canadian National Railway Relocation and Beauharnois Valleyfield Canadian Railway and highway bridge across canal
K — L New York Central Railway Relocation and Beauharnois Valleyfield Railway overpass across canal
M — N Public highway bridge across tailrace
O — P Canal Control Works - Concrete dam with 6 sluices
Q — R Cotteau Remedial and Control Works - Concrete sluiceway and bridge
S — T Cotteau Remedial and Control Works - Rock fill dam with bridge
U — V Shore Protection Work - Rock Fill
W — X Cedars Remedial Work - Rock fill dam

BEAUHARNOIS LIGHT HEAT AND POWER COMPANY

GENERAL PLAN

SHOWING

BEAUHARNOIS POWER DEVELOPMENT

AND

ACCESSORY WORKS

Scale in feet

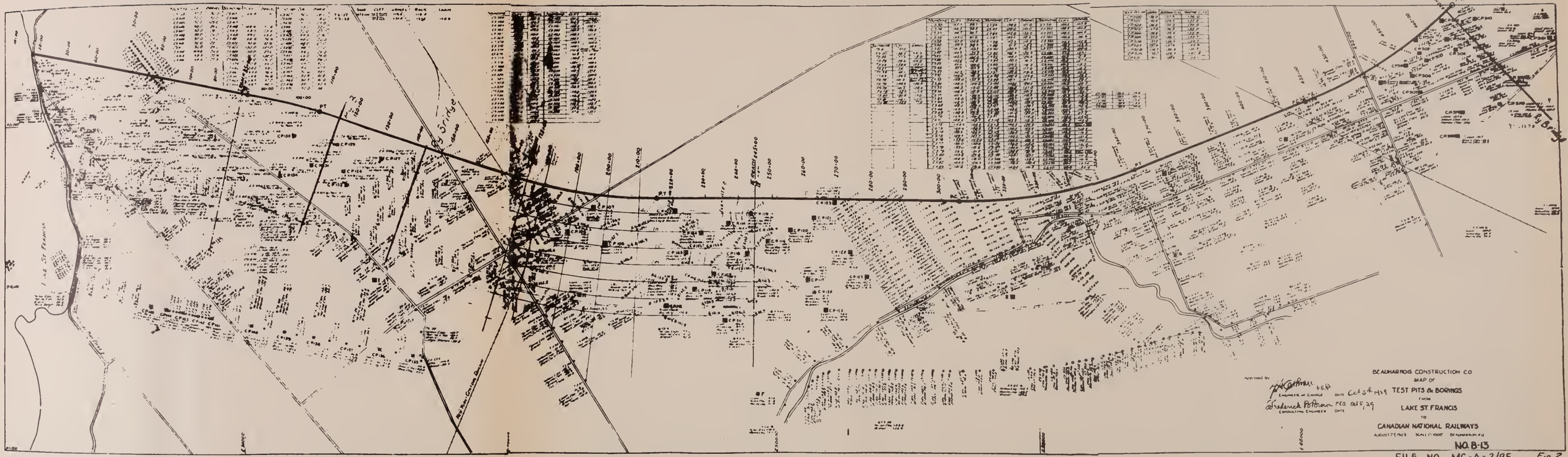
Compiled by J. Lovell

Approved by — R. L. Chaney

Montreal, July 13, 1944.

FILE NO. MC A-2/44

Fig 1


BEAUHARNOIS CONSTRUCTION CO
MAP OF
TEST PITS & BORINGS
FROM
LAKE ST FRANCIS
TO
CANADIAN NATIONAL RAILWAYS
NO. B-13
FILE NO. MC-A-2/95
Fig 2

FILE NO. MC-A-2/96 Fig. 3

500+00 600+00 700+00

Ground Surface

Brown Clay

Marine Clay

Sand and Gravel

NORTH DIKE ⟶ downstream

C.N.R. Per. Way

500+00 600+00 700+00

Ground Surface

Brown. Clay

Marine Clay

Sand and Gravel

SOUTH DIKE ⟶ downstream

C.N.R. Per. Way

▫ Gravel determined by soundings

↕ No gravel to depth of sounding

Rock determined in bridge caissons

BEAUHARNOIS CANAL

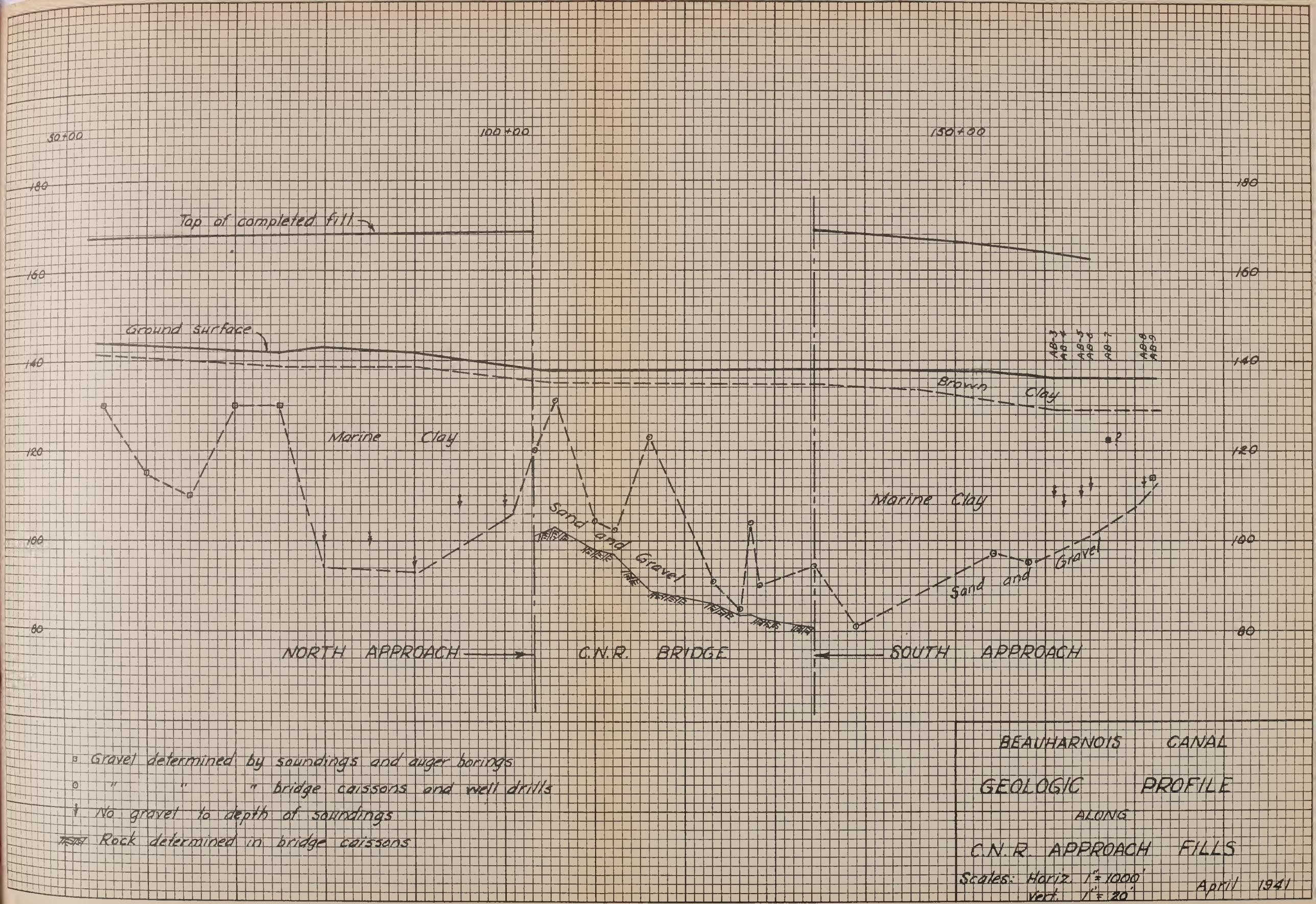
GEOLOGIC PROFILES OF NORTH AND SOUTH DIKES

Scales: Horiz. 1"=200'
Vert. 1"=20'

April 1941

FILE NO. MC-A-2/97

Fig. 4



▫ Gravel determined by soundings and auger borings

⊙ " " " bridge caissons and well drills

ǀ No gravel to depth of soundings

Rock determined in bridge caissons

BEAUHARNOIS CANAL

GEOLOGIC PROFILE

ALONG

C.N.R. APPROACH FILLS

Scales: Horiz. 1" = 1000'
Vert. 1" = 20'

April 1941

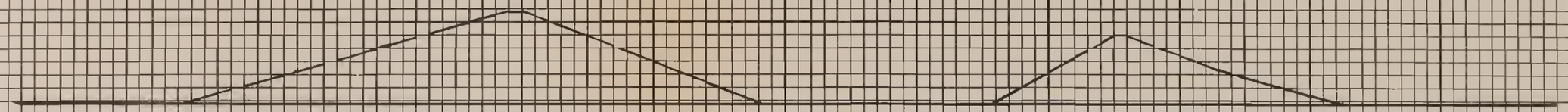
FILE NO. MC-A-2/98

Fig. 5

Distance from North → 1200 — 1300 — 1400 — 1500

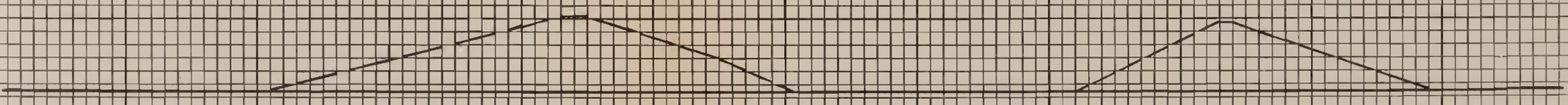
"A" Dikes — "B" Dikes

Sta. 682+00



Sta. 660+00

Sta. 612+00



Sta 588+00

BEAUHARNOIS CANAL

TYPICAL CROSS SECTIONS

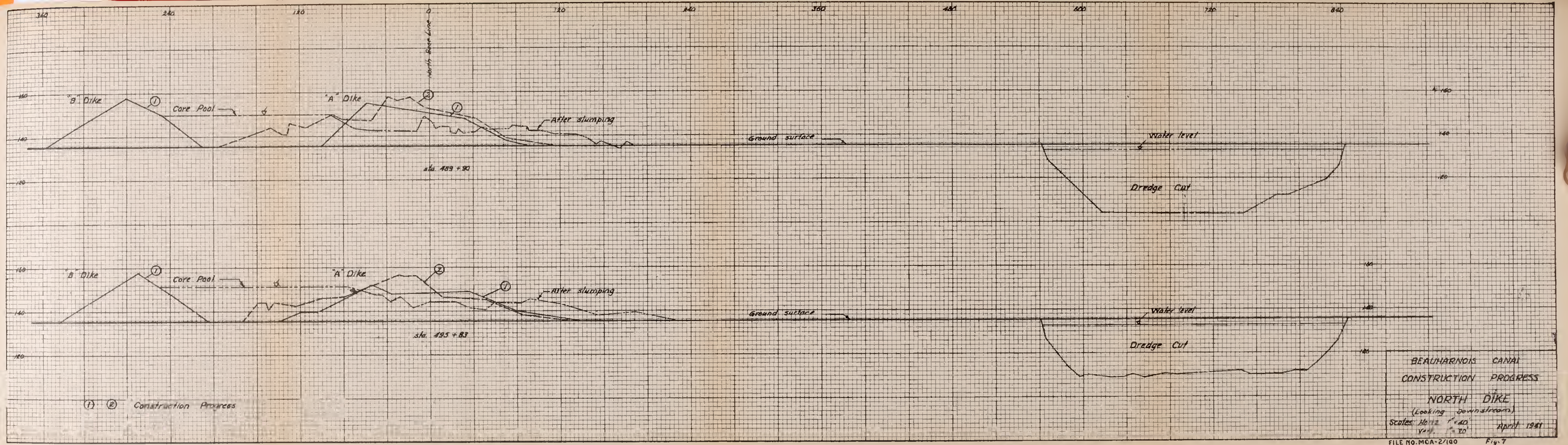
SOUTH DIKE

(Looking Downstream)

Scale: 1" = 40' April 1941

FILE NO. MC-A-2/99

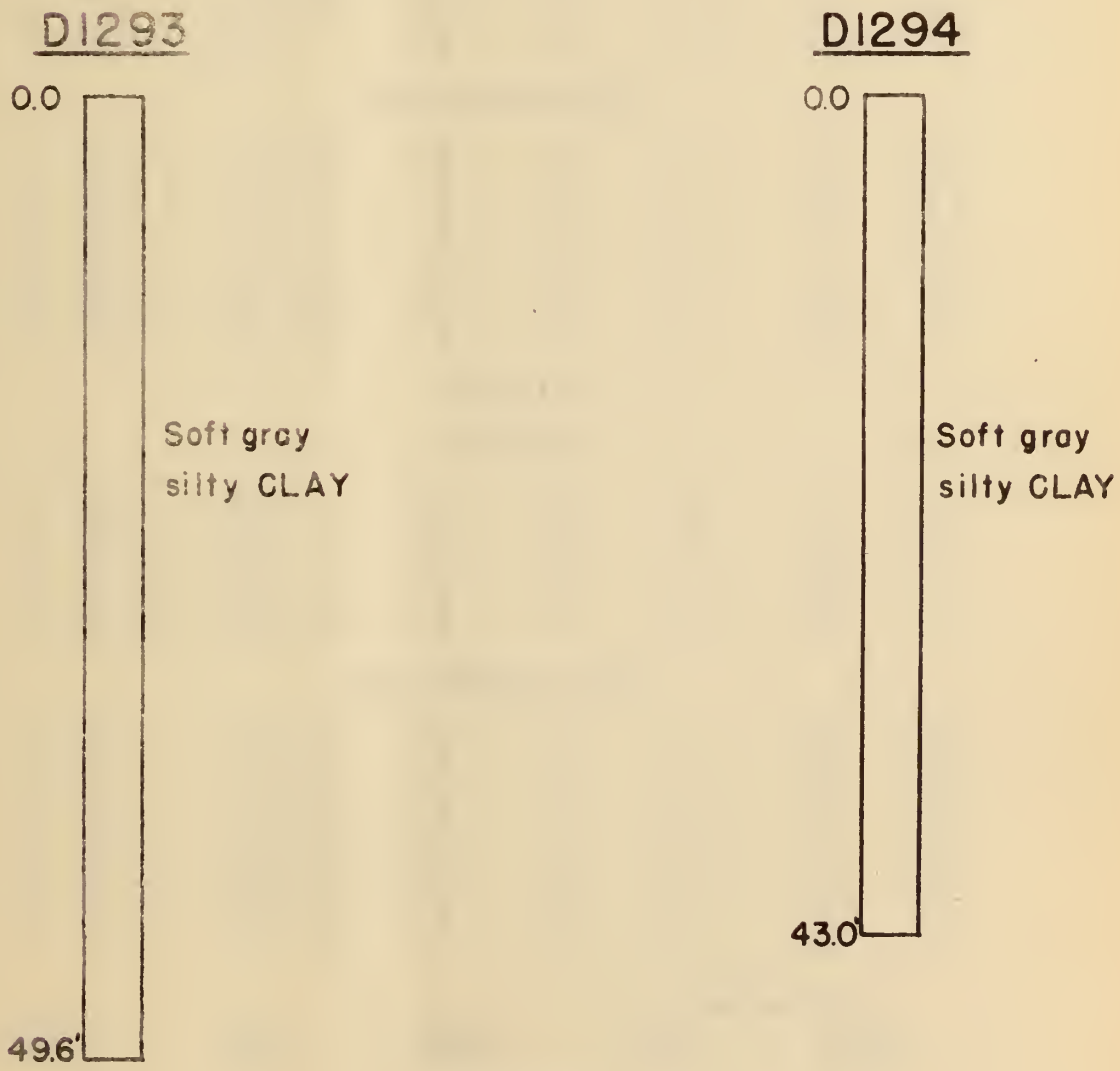
Fig. 6


North Basin Line
"B" Dike
Core Pool
"A" Dike
After slumping
Ground surface
Water level
Dredge Cut
Sta. 199 + 50
Sta. 195 + 83
① ② Construction Progress
BEAUHARNOIS CANAL
CONSTRUCTION PROGRESS
NORTH DIKE
(Looking Downstream)
Scales: Horiz. 1"=40'
Vert. 1"=20'
April 1981
FILE NO. MCA-2/100
Fig. 7

BEAUHARNOIS CANAL

RECORD OF EXPLORATION

6-inch Drill Holes



FILE NO. MC-A-2/101

PLATE A-1

TEST RESULTS
BEAUHARNOIS CANAL

TRIAXIAL SHEAR TEST RESULTS

No.	Ithaca Test No.	Cyl. No.	Depth (ft.)	σ_3 (tsf)	Max. σ_1 (tsf)	Strain at Max. (%)	Time to Reach Max. (Minutes)	Original w (%)	Final w (%)
					Hole D-1293				
					Quick Test				
1	111	2	7.4		0.10	4.8	2.5	88.5	
2	109	5	13.0		0.17	2.5	1.5	87.5	
3	110	5	13.0		0.14	2.7	1.5	87.0	
4	154	9	21.0	0.43	0.71	8.1	4.5	70.5	70.0
5	155	9	21.0	1.08	1.37	8.5	4.5	72.6	71.0
6	156	10	23.0	2.16	2.50	5.9	3.0	75.4	73.6
7	114	16	34.3		0.32	3.5	2.0	80.6	79.5
					Consolidated-Quick Tests				
8	118	2	7.4	0.43	0.86	3.1	1.5	90.4	79.5
9	117	3	9.2	1.08	1.75	3.6	2.0	85.4	60.0
10	116	3	9.2	2.16	3.31	2.8	1.5	84.1	48.4
11	115	6	15.0	0.43	0.88	2.7	1.5	84.5	78.7
12	113	7	17.0	1.08	1.68	3.2	2.0	74.8	65.9
13	112	7	17.0	2.16	3.29	3.7	2.0		45.7
14	122	16	34.3	0.47	1.14	3.9	2.5	82.8	79.0
15	123	17	35.9	1.08	2.22	3.3	2.0	84.0	75.7
16	123	17	35.9	2.16	3.58	4.1	2.5	81.3	63.1
					Hole D-1294				
					Quick Test				
1	119	2	6.0		0.12	2.6	1.5	74.0	
2	120	2	6.0		0.15	4.4	2.5		
3	169	8	15.5	0.35	0.68	8.9	5.0	88.1	86.5
4	127	10	19.7		0.27	4.0	2.5	92.2	
5	175	14	27.5	1.44	1.82	9.9	5.0	67.9	66.5
6	124	16	32.0		0.19	2.5	1.5	70.7	
7	170	18	36.0	0.81	1.15	17.0	9.0	46.3	40.0
					Consolidated-Quick Tests				
8	128	4	8.8	0.43	0.89	2.9	1.5	88.6	79.8
9	126	5	10.9	1.08	1.78	3.5	2.0	85.9	61.4
10	125	5	10.9	2.16	3.40	3.0	1.5	70.2	35.9
11	134	10	19.7	0.43	1.07	4.4	2.5	89.7	85.0
12	129	11	21.7	1.08	2.16	3.7	2.0	71.7	59.6
13	130	11	21.7	2.16	3.53	4.6	2.5		65.2
14	133	16	32.0	0.43	0.87	3.6	2.0	71.5	68.1
15	132	17	33.9	1.08	1.86	8.4	4.5	54.0	45.9
16	131	17	33.9	2.16	3.20	3.8	2.0	64.3	48.4

Cylinder Number	Depth (feet)	Specific Gravity	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Limit
		Hole D-1293		
1	6.5	2.72	61.1	25.5
6	15.2	2.73	56.8	27.4
12	26.9	2.72	55.1	32.0
		Hole D-1294		
3	7.9	2.74	66.6	29.0
8	15.5	2.76	60.8	32.5
13	25.6	2.79	54.4	31.5
18	36.0	2.76	30.2	19.8

MC-A-2/108
PLATE No. A-2

ST. LAWRENCE RIVER DISTRICT

D1293 BEAUHARNOIS CANAL

TRIAXIAL SHEAR TEST RESULTS

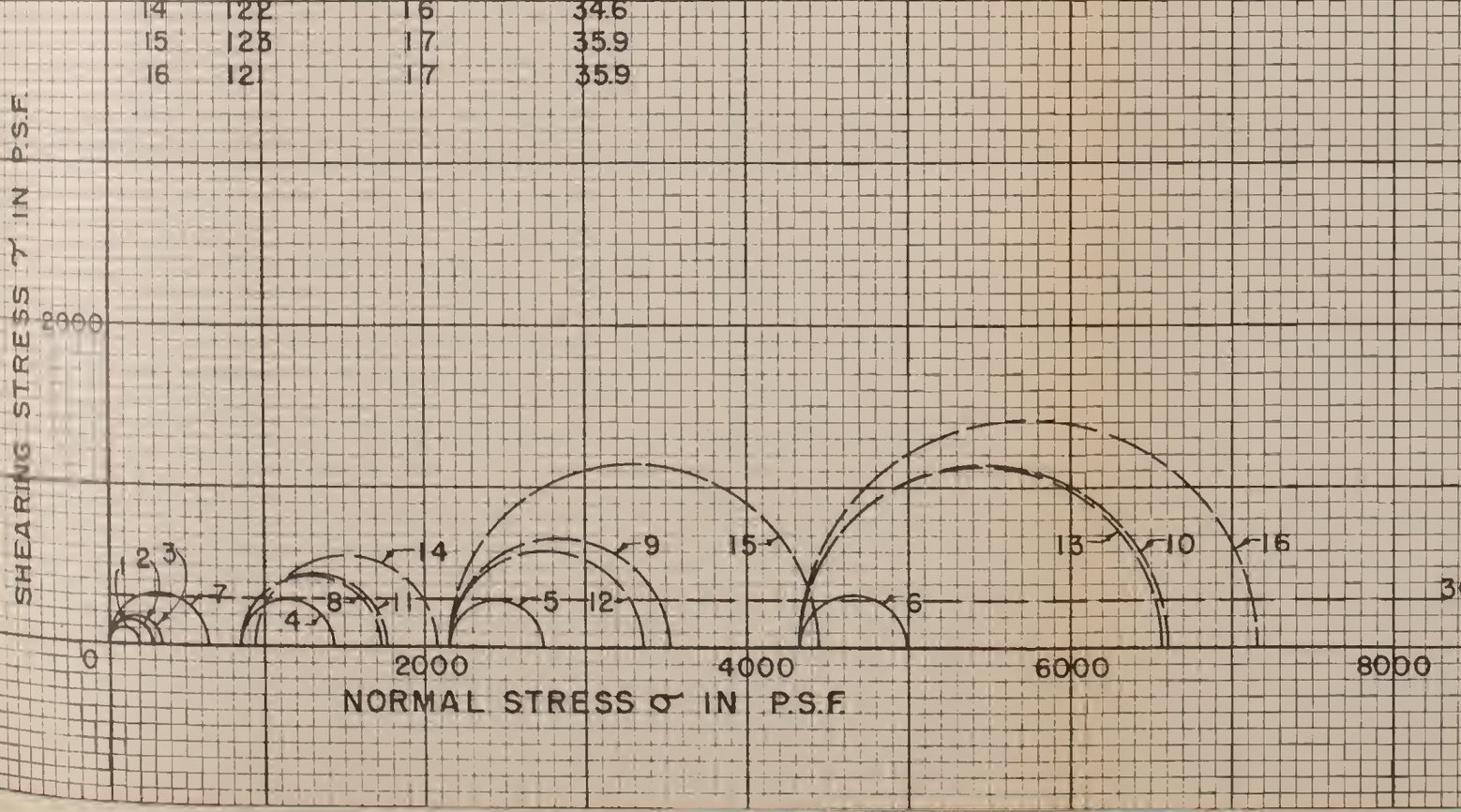
SPECIMENS 2.8" X 5.6"

NO.	ITHACA TEST NO.	CYLINDER NO.	DEPTH FEET
1	111	2	7.4
2	110	5	13.0
3	109	5	13.0
4	154	9	21.0
5	155	9	21.0
6	156	10	23.0
7	114	16	34.3
8	118	2	7.4
9	117	3	9.2
10	116	3	9.2
11	115	6	15.0
12	113	7	17.0
13	112	7	17.0
14	122	16	34.6
15	123	17	35.9
16	121	17	35.9

LEGEND

——— CONSOLIDATED QUICK TESTS

——— QUICK TESTS



FILE NO. MC-A-2/102

PLATE A-3

ST. LAWRENCE RIVER DISTRICT

DI294 BEAUHARNOIS CANAL

TRIAXIAL SHEAR TEST RESULTS

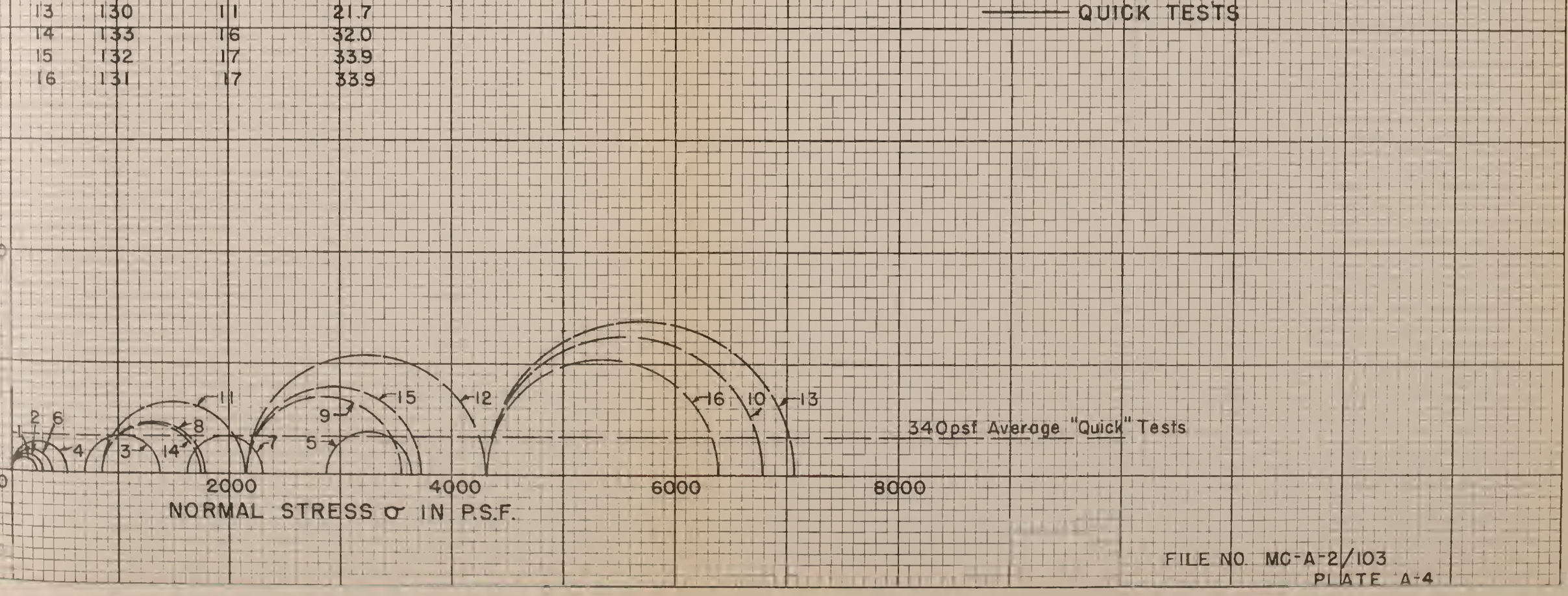
SPECIMENS 2.8" X 5.6"

NO.	ITHACA TEST NO	CYLINDER NO.	DEPTH FEET
1	119	2	6.0
2	120	2	6.0
3	169	8	15.5
4	127	10	19.7
5	175	14	27.5
6	124	16	32.0
7	170	18	36.0
8	128	4	8.8
9	126	5	10.9
10	125	5	10.9
11	134	10	19.7
12	129	11	21.7
13	130	11	21.7
14	133	16	32.0
15	132	17	33.9
16	131	17	33.9

LEGEND:

——·—·— CONSOLIDATED QUICK TESTS

——— QUICK TESTS



FILE NO. MC-A-2/103

PLATE A-4

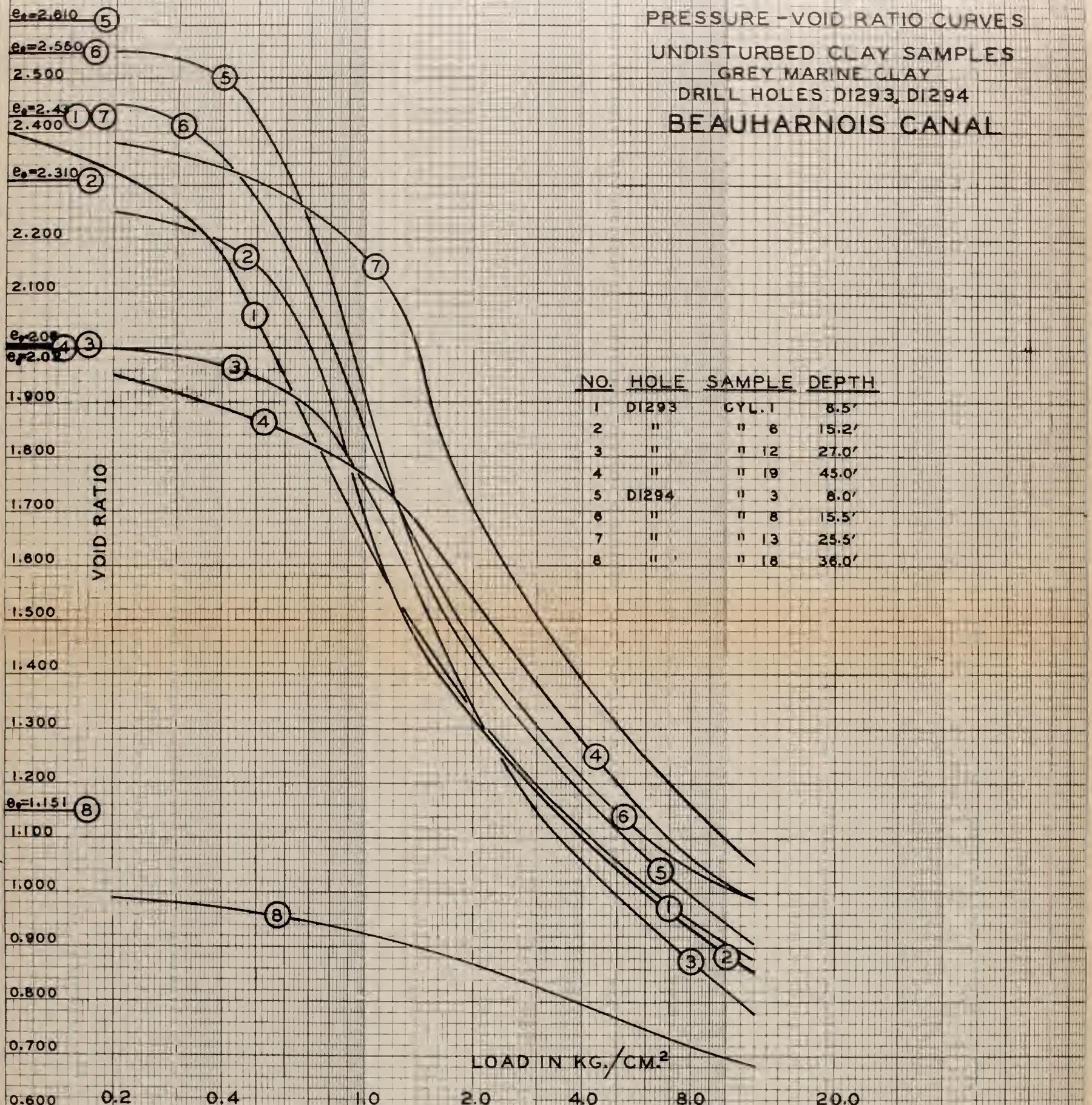
PRESSURE - VOID RATIO CURVES

UNDISTURBED CLAY SAMPLES

GREY MARINE CLAY

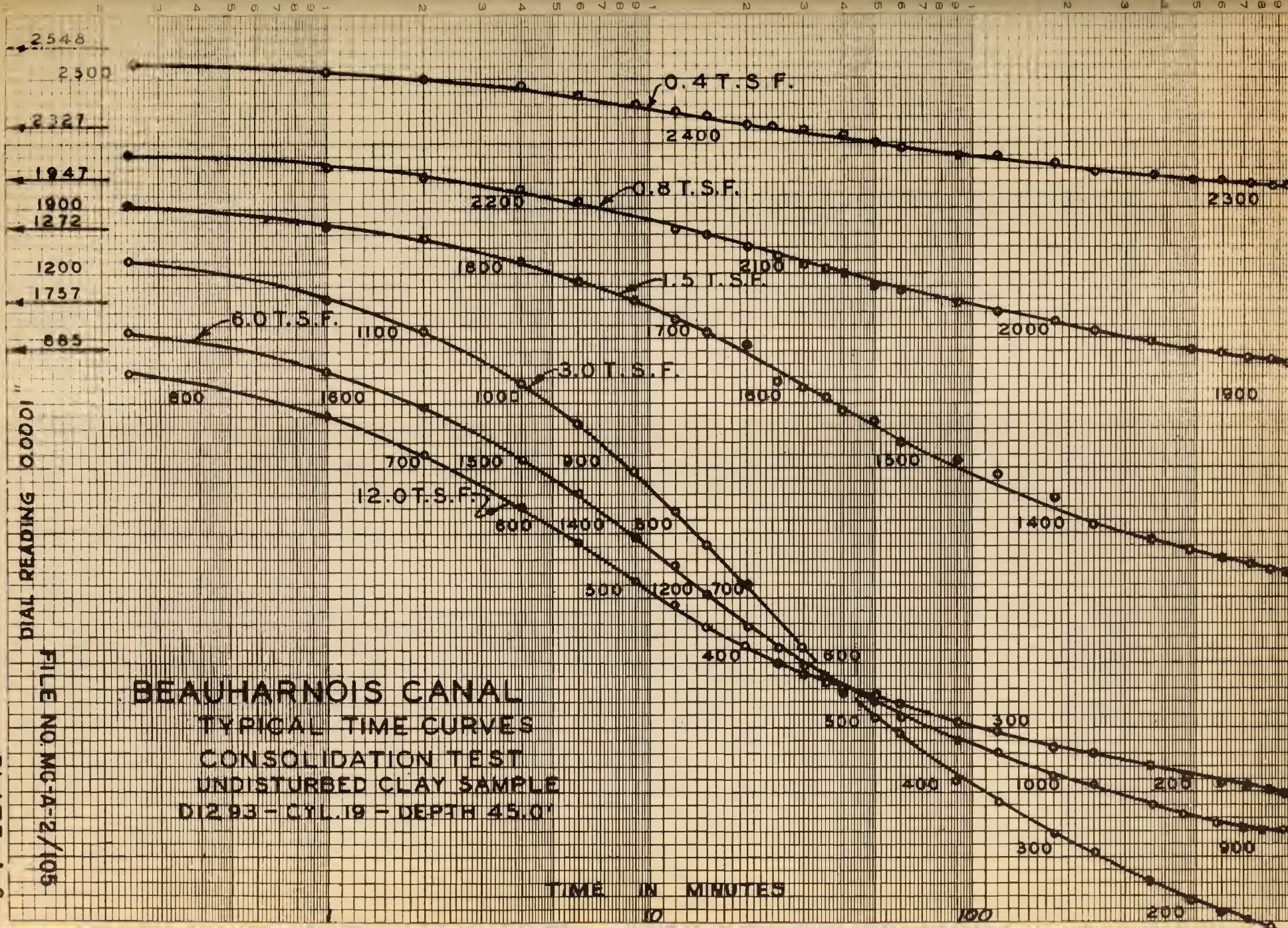
DRILL HOLES D1293, D1294

BEAUHARNOIS CANAL



NO.	HOLE	SAMPLE	DEPTH
1	D1293	CYL. 1	8.5'
2	"	" 6	15.2'
3	"	" 12	27.0'
4	"	" 19	45.0'
5	D1294	" 3	8.0'
6	"	" 8	15.5'
7	"	" 13	25.5'
8	"	" 18	36.0'

FILE NO. MC-A-2/104 PLATE A-5


2548
2500
2327
1947
1900
1272
1200
1757
685
0.4 T.S.F.
2400
2300
0.8 T.S.F.
2200
2100
1800
1.5 T.S.F.
2000
1700
1900
6.0 T.S.F.
1100
3.0 T.S.F.
800
1600
1000
1800
700
1500
900
1500
12.0 T.S.F.
600
1400
800
1400
500
1200
700
400
600
500
300
400
1000
200
300
900
200
DIAL READING 0.0001"
TIME IN MINUTES
1
10
100
200
BEAUHARNOIS CANAL
TYPICAL TIME CURVES
CONSOLIDATION TEST
UNDISTURBED CLAY SAMPLE
D12 93 - CYL. 19 - DEPTH 45.0'
FILE NO. MG-A-2/105
PLATE A-6

MECHANICAL ANALYSIS

SIEVE ANALYSIS — HYDROMETER ANALYSIS

SIZE OPENING IN INCHES — NO. MESH PER INCH

SIZE OPENING IN INCHES							NO. MESH PER INCH											
28	18	8	4	"A" 2	"B" 1.03	"C" 0.742	"D" 0.526	"E" 0.371	3	4	6	8	10	14	20	28	35	48	85	100	150	200	250

SITE BEAUHARNOIS CANAL
HOLE ..
DEPTH ...
SAMPLES ..
PLOTTER ...
DATE .....

	HOLE	SAMPLE	DEPTH
①	D1293	6	15.2'
②	D1294	8	15.0'-16.0'

% FINER BY WEIGHT

% RETAINED

GRAIN SIZE IN MM

M I T SOIL CLASSIFICATION

FILE NO. MC-A-2/107

DERRICK	ONE MAN	SMALL	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	COLLOIDAL
STONE*			GRAVEL*			SAND			SILT			CLAY		

* These sizes not included in original M I T Classification

PLATE A-7

SL - 5.00

PART TWO

LONG SAULT CANAL

ESTIMATE OF COST

March 22, 1942

LONG SAULT CANAL

SCHEDULE OF BID PRICES

ESTIMATED UNIT PRICES

Item No.	Designation	Unit	Quantity	Unit Price	Amount
1	Excavation, Long Sault Canal	C.Y.	15,699,000	$ .40	$6,267,600
2	Earth Fill; Compacted, Class I	C.Y.	236,000	.12	28,320
3	Earth Fill; Compacted, Class II	C.Y.	1,392,000	.10	139,200
4	Earth Fill; Class III	C.Y.	1,646,000	.08	131,680
5	Additional Rolling	square (100sf)	75,000	.02	1,500
6	Stripping; Dike Foundations	C.Y.	207,000	.35	72,450
7	Riprap	C.Y.	193,000	1.50	289,500
8	Filter	C.Y.	35,000	2.00	70,000
9	Sand and Gravel Backing	C.Y.	33,000	1.75	57,750
10	Seeding	square (100sf)	10,200	.60	6,120
	Total				$7,063,960
	Engineering and Contingencies 18% ±				1,271,040
	Total Cost of Feature No. 16				$8,335,000

DOCUMENTS Room 8

ST. LAWRENCE RIVER PROJECT

FINAL REPORT 1942

LONG SAULT DAM SPECIFICATIONS

CORPS OF ENGINEERS, U.S. ARMY

U.S. ENGINEER OFFICE • MASSENA, NEW YORK.

APPENDIX III-22 (2)

S T. L A W R E N C E R I V E R

P R O J E C T

* * * * *

F I N A L R E P O R T

1 9 4 2

L O N G S A U L T D A M

S P E C I F I C A T I O N S

CORPS OF ENGINEERS, U.S. ARMY

U.S. Engineer Office, Massena, New York

July , 1942

APPENDIX III-22 (2)

This appendix consists of two parts as follows:

PART ONE - GENERAL SPECIFICATIONS.

PART TWO - PURCHASE SPECIFICATIONS.

PART ONE

LONG SAULT DAM

GENERAL SPECIFICATIONS

Long Sault Dam Invitation No._____

No._____ Bidder_____

(Do not write above this line)

STANDARD GOVERNMENT FORM OF INVITATION FOR BIDS

(CONSTRUCTION CONTRACT)

WAR DEPARTMENT
UNITED STATES ENGINEER OFFICE
MASSENA, NEW YORK
_____, 194

1. SEALED BIDS, in duplicate, subject to the conditions contained herein, will be received until 2:00 P.M. E.S.T., _____ and then publicly opened in the United States Engineer Office, Massena, New York, for furnishing all labor, plant, and materials, and performing all work for the construction of Long Sault Dam, on the St. Lawrence River, about 4 miles north of the village of Massena, New York, all as indicated on the drawings or required by the specifications.

2. SPECIFICATIONS AND PLANS.

(a) The work shall be done in strict accordance with the specifications and drawings which are designated as follows:

(1) Long Sault Dam ,specifications.

(2) The drawings which will become a part of this contract are designated in paragraph 1-04 of the specifications.

(b) Where copies of drawings are requested, a deposit of twenty-five dollars ($25.00) will be required to insure their return. The deposit should be in the form of a United States money order or a certified check made payable to "The Treasurer of the United States." The deposit will be refunded upon the return of the plans in good condition within 30 days after date of opening bids.

3. INVESTIGATION OF CONDITIONS. - Bidders are expected to visit the locality and site of the work, and to make their own estimates of the facilities needed, and the difficulties attending the execution of the proposed contract, including local conditions, availability of labor, uncertainty of weather, and other contingencies. In no case will the Government assume any responsibility whatever for any interpretation, deduction, or conclusion drawn from the examination of the site. At the bidder's request, a representative of the Government will point out the site of the proposed operation. Failure to acquaint himself with all available information concerning these conditions will not relieve the successful bidder of assuming all responsibilities for estimating the difficulties and costs of successfully performing and completing the work. (See paragraphs 1-18 and 1-19 of the specifications.)

4. WAGE AND LABOR PROVISIONS. - Wage, labor, and anti-discrimination regulations are specified in paragraph 1-38 of the specifications and Articles 11 (Revised), 17, and 19 (Revised) of the contract. Attention of bidders is invited to War Department Labor policy for defense construction projects set out

in memorandum of agreement approved July 22, 1941. Successful bidders will be expected to adhere to provisions of the agreement, copies of which are on file at the office of District Engineer, U. S. Engineer Office, Massena, N.Y.

5. DOMESTIC PREFERENCE. - Articles on the preference for domestic articles will be made a part of the contract. (See paragraph 1-35 of the specifications).

6. ARTICLES ON PATENTS will be made a part of the contract. (See paragraph 1-30 of the specifications.)

7. COMMENCEMENT AND COMPLETION.- The work shall be commenced within 10 calendar days after date of receipt of notice to proceed and shall be completed _____, in accordance with the provisions of paragraph 1-06 of the specifications.

8. EXTENSION OF TIME FOR COMPLETION OF CONSTRUCTION FOR DELAYS DUE TO NATIONAL DEFENSE PRIORITIES will be made. (See paragraph 1-06 (c) of the specifications.)

9. LIQUIDATED DAMAGES for delay will be prescribed. (See paragraph 1-06 of the specifications.)

10. PARTIAL PAYMENTS will be made. (See paragraph 1-08 of the specifications and Article 16 of the contract.)

11. ADJUSTMENT OF CONTRACT PRICE by reason of change in Federal, State, and local taxes will be made. (See paragraph 1-42 of the specifications.)

12. ADJUSTMENT OF PRICES FOR LABOR AND MATERIALS. Adjustment of prices in accordance with basic increase or decrease of costs of labor and material will be made as provided in paragraph 1-46 of the specifications.

13. ESTIMATES OF COST. - Bidders are informed that the Government will prepare estimates of the cost of construction of the work required by the specifications for comparison of bids.

14. REPORTS TO THE DEPARTMENT OF LABOR. - In order to assist the Department of Labor in obtaining employment statistics, bidders, unless otherwise indicated in their bids, will be considered as having voluntarily consented, without cost to the Government, to the inclusion of paragraph 1-39 of the specifications as a part of the contract.

15. BID AND CONTRACT.

(a) Bids must be submitted upon the standard Government form of bid, and the successful bidder will be required to execute the standard Government form of contract for construction (U.S. Standard Form No. 23). Bidders are advised that Article 11 (a) of U.S. Standard Form No. 23 has been revised to permit laborers and mechanics to work more than 8 hours per day, provided overtime compensation at a rate of not less than 1-1/2 times the basic rate of pay is paid for all working time of each laborer or mechanic in excess of 8 hours in any one day. Also Article 19, Nonrebate of U.S. Standard Form No. 23, is revised to read as follows, and the contract to be entered into as a result of this invitation will be altered accordingly:

"ARTICLE 19. Nonrebate. (a) The contractor shall furnish to the Government representative in charge at the site of the work covered by this contract, or if no Government representative is in charge at the site, shall mail to the Federal agency contracting for the work, within 7 days after the regular payment date of each and every weekly payroll, an affidavit in the form prescribed by regulations issued by the Secretary of Labor and published in the Federal Register of March 1, 1941, 6 F. R. 1211, or any modification thereof pursuant to the act of June 13, 1934, 48 Stat. 948 (U. S. Code title 40, sections 276b and 276c), sworn to by the contractor or the subcontractor concerned or by the authorized officer or employee of the contractor or subcontractor supervising such payment, to the effect that each and every person employed on the work has been paid in full the weekly wages shown on the pay roll covered by the affidavit, that no rebates have been or will be made either directly or indirectly to or on behalf of the contractor or such subcontractor from the full weekly wages earned as set out on such payroll; and that no deductions, other than permissible deductions as defined in the said regulations pursuant to said act of June 13, 1934, and as described in said affidavit, have been or will be made, either directly or indirectly, from the full weekly wages earned as set out on such pay roll.

"(b) The contractor shall comply with all applicable requirements of the said regulations of the Secretary of Labor under the act of June 13, 1934, and the requirements of this article of the contract shall be subject to all applicable provisions of such regulations.

"(c) The contractor shall cause appropriate provisions to be inserted in all subcontracts relating to this work to insure fulfillment of the requirements of this article."

(b) The bid form has an entry for each item on which estimates will be given or payments made, and no other allowance of any kind will be made unless specifically provided for in the specifications or the contract, or adjustments under Article 3 of the contract.

(c) All bids must be for the entire work and must have each blank filled.

(d) The quantities of each item of the bid as finally ascertained at the close of the contract, in the units given, and the unit price of the several items stated by the bidder in the accepted bid, will determine the total payments to accrue under the contract. The unit price bid for each item must allow for all collateral or indirect cost connected with it.

16. DATA TO BE SUBMITTED WITH BIDS.

(a) All bids submitted must be accompanied by a statement establishing that the bidder maintains a permanent place of business and has a suitable financial status to meet obligations incident to the work. (See paragraph 3 of the bidding schedule.) In addition, each bidder shall submit with his bid the statement of plant, drawings, charts, and other information and data required below. These data shall be carefully prepared and presented in neat and legible form on tracing paper or tracing cloth so that reproduction may be made therefrom. These data are considered essential in enabling the contracting officer to determine whether the bidder is responsible and experienced in similar types of construction and whether the bid is based on a careful study of construction methods applicable to the work and full realization of the various factors which may affect the progress of the work. Award of this contract shall not be construed as a guarantee by the Government that the materials or supplies listed in the bidding schedule are approved.

(b) Each bidder shall state in the space provided in the bidding schedule a brief description of the character of the work previously executed by him and the locations of the major projects. After the bids are opened, any bidder may be required by the contracting officer to state whether he is now or ever has been engaged on any construction work similar to that proposed, the year in which it was done, and the manner of its execution, and to give such other information as will tend to show his ability to prosecute vigorously the work required by these specifications. (See paragraph 2 of the bidding schedule.)

(c) Drawings shall be submitted indicating the plant layout the bidder proposes to utilize on the work. The drawings shall clearly indicate the location and manner of employment of the various major items of the plant. They shall include the location, construction, and height of each cofferdam, the arrangement of the plant for the handling of materials, and the manner in which excavation and disposal of the excavated materials will be made. They shall also include the location of all material yards and the transportation facilities, as well as the location of the mixing plant and the manner in which concrete will be placed and metalwork erected. The plant lay-out shall be accompanied by a complete list and description inserted in the space provided therefor in the bid form, of all plant that the bidder now has or will have available for commencing and prosecuting this work, and its location at the time of opening bids, in order that it may be inspected by the contracting officer should he so desire. The above information will be considered confidential. When a bidder does not own or possess plant and proposes to procure it, firm options on all major items of proposed plant must be submitted when the bids are opened.

(d) A chart or charts shall be submitted indicating the volume of work to be done and the rate of progress which the bidder agrees to maintain (see paragraph 1-20 of the specifications) for each of the following major operations required in the performance of the work under these specifications:

(1) Cofferdams.
(2) Diversion Gates.
(3) Closure of spillway.
(4) Excavation and Foundation Preparation.
(5) Concrete Masonry.
(6) Embankment.
(7) Gantry Cranes and Hoists
(8) Spillway Gates.

Charts shall be in the form of plotted curves in which the abscissae shall represent definite intervals of time measured from date of receipt of notice to proceed with the work, and the ordinates shall represent percentages of completion based on the estimated contract quantities. In preparing the charts, due allowance shall be made for probable delays caused by any unsatisfactory working conditions. Careful consideration shall be given to the preparation of these charts, as the rate of progress proposed by the accepted bid will be made a part of the contract. (See paragraph 1-20 of the specifications.)

17. AWARD OF CONTRACT.

(a) Subject to the rights hereinafter reserved, work will be awarded as a whole to the lowest responsible bidder whose proposal fully conforms to the requirements of the specifications and as may be deemed most advantageous to the United States.

(b) A bid may be rejected if the bidder fails to furnish bid bond or to submit the data required with his bid or cannot show that he has the necessary capital and experience and owns, controls, or can procure the necessary plant to commence the work at the time prescribed in the specifications and thereafter to prosecute and complete the work at the rate or time specified; and that he is not already obligated for the performance of other work which would delay the commencement, prosecution, or completion of the work contemplated in this advertisement.

(c) Any unbalanced bid which, in the opinion of the contracting officer, jeopardizes the interest of the United States will be subject to rejection for that reason.

(d) The right is reserved, as the interest of the Government may require, to reject any and all bids and to waive any informality in bids received.

18. GUARANTY. - Guaranty will be required with each bid as follows: Bid Bond, Standard Form No. 24, will be executed in a penal sum not less than 10 percent of the total amount of the bid, but not exceeding $2,500,000. Individual sureties will justify in sums aggregating not less than double the penalty of the bid bond. (See paragraphs 8 and 9 of the Instructions to Bidders).

19. PERFORMANCE AND PAYMENT BONDS will be required as follows:

(a) A performance bond with good and sufficient surety or sureties, for the protection of the United States, Standard Form No. 25, will be executed in a penal sum not less than ten percent (10) of the full amount of the consideration of the contract, but not exceeding $2,500,000.

(b) If the consideration of the contract will exceed $2,000 in amount, a payment bond with good and sufficient surety or sureties, for the protection of persons furnishing material and labor for the work, Standard Form No. 25-A, will be executed in a penal sum of one-half of the full amount of the consideration of the contract when the latter is not more than one million dollars ($1,000,000); forty percent (40%) where the contract exceeds one million dollars($1,000,000) but is not more than five million dollars ($5,000,000); and two million five hundred thousand dollars ($2,500,000) for all contracts above five million dollars ($5,000.000).

20. PROVISIONS OF THE ASSIGNMENT OF CLAIMS ACT of October 9, 1940, (Public No. 811-76th Congress) will be made a part of the contract. (See paragraph 1-45 of the specifications.)

21. ADDRESS FOR BIDS. - Envelopes containing bids must be sealed, marked, and addressed as follows:

Mark in upper left hand corner:
Bid for Construction of Long Sault Dam

Invitation No._____
To be opened at 2:00 P.M. E.S.T.,

Address:
To: The District Engineer
U. S. Engineer Office
Massena, New York

Note: See standard Government Instructions to Bidders and copy of the Standard Government Form of Contract, Bid Bond, Payment Bond, and Performance Bond, which may be obtained upon application.

Specifications: Long Sault Dam

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V	Concrete
VI	Bridge and Roadway
VII	Spillway Gates, Gantry Cranes, Fixed Hoists, and Appurtenances
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WAR DEPARTMENT
U. S. Engineer Office
St. Lawrence River District
Massena, N. Y.

Specifications: Long Sault Dam

Appropriation:

SECTION I - GENERAL PROVISIONS

1-01. LOCATION. - The site of the work is located in the International Rapids Section of the St. Lawrence River, about 4 miles north of the village of Massena, New York, and 6.5 miles west of Cornwall, Ontario. The site may be reached by Federal and State Highways on the United States side of the St. Lawrence River and by Highway No. 2 on the Canadian side. (For transportation facilities, see paragraph 1-19).

1-02. WORK TO BE DONE.

(a) The work provided herein is authorized by_____ Act, approved_____,194 .

(b) The work to be done under this contract and in accordance with these specifications consists of furnishing all plant, superintendence, labor and materials, except as noted in paragraph 1-10, and performing all work required for the construction of the Long Sault Dam, except for specifically excepted items, with appurtenant works, complete in accordance with the drawings and these specifications. The main features of the work are as follows:

(1) Excavation for and construction of cofferdams for the concrete dam sections, including maintenance, unwatering and removal, excavation of cuts required for diversion purposes, and operations, and removal of diversion gates. (See Section II).

(2) Excavation for foundations of concrete structures including foundation preparation and grouting, excavation of core trench and stripping foundation for earth fill. (See Section III).

(3) Construction of rolled earth fill wing dams and dikes complete, including stripping foundation, placing and compacting embankment, placing protective riprap, and seeding. (See Section IV).

(4) Construction of the concrete dam, including placing concrete, reinforcement, and embedded parts for the spillway, bulkheads, spillway apron training walls and appurtenant works.

(5) Erection and installation of forty fixed wheel, vertical lift gates, including lifting and latching mechanisms for the spillway crest, plus two emergency gates and miscellaneous mechanical gate equipment. (See Section VII).

(6) Erection and installation of two gantry cranes and eighteen fixed hoists under the supervision of an erection engineer furnished and paid for by the crane and hoist manufacturer. (See Section VII).

(7) Construction of two pier houses and four guard houses complete. (See Section XI).

(8) Temporary and permanent access railroads and highways, as shown on the contract drawings. (See Section XIII).

(9) Miscellaneous items including embedded electrical conduit system, operating, maintenance and repair bays, Government field office, and other work as specified or shown on the drawings, and such incidental work as may be needed or ordered in writing by the con-

tracting officer.

1-03. DESCRIPTION.

Long Sault Dam will be a concrete gravity structure having a maximum height of approximately 145 feet above foundation. It will have an overflow spillway flanked by concrete gravity bulkhead sections and earth wing dams and an earth dike, and will be provided with vertical lift gates on the spillway crest, a spillway apron and the necessary training and spray walls. The crest lenth of the spillway will be 2,390 ft. including thirty-nine nominal 10-foot bridge piers. The spillway crest will be at Elevation 221. The concrete bulkhead section on each end of the spillway will be approximately 260 ft. in length. Forty 50' x 25' vertical lift gates will be installed on the crest of the overflow section of the concrete spillway. Eighteen of the gates will be operated by fixed hoists and the remainder by two traveling gantry cranes. The spillway apron will be a curved or bucket type concrete structure. The wing dams and dike will be of rolled earth protected on both sides with riprap, as shown on the drawings.

1-04. MAPS AND DRAWINGS.

(a) The work shall conform to maps and drawings marked "St. Lawrence River Project, Long Sault Dam," titled and file marked as listed below, which form a part of these specifications and which are filed in the U. S. Engineer Office, St. Lawrence River District, Massena, New York.

LIST OF DRAWINGS

L O N G S A U L T D A M

Sheet No.	Title	File No.
	GENERAL	
1	Index Sheet	BD-1-0/1
2	General Site Map	1/1
3	General Plan and Elevations	1/2
4	Mean Monthly Discharges - St. Lawrence River 1860-1941	1/3
5	Winter Tailrace Elevation - Sheek Island Powerhouse	1/4
6	Plan of Soils & Foundations Exploration	1/5
7	Record of Foundation Exploration No. 1	1/6
8	Record of Foundation Exploration No. 2	1/7
9	Record of Foundation Exploration No. 3	1/8

Sheet No.	Title	File No.
	COFFERDAM	
10	Cofferdams - General Layout	BD-1-5/1
11	First Step Cofferdams - Plan and Sections	5/2
12	Second Step Cofferdams - Plan and Sections	5/3
13	Second Step Cofferdams - Plan and Sections	5/4
14	Cofferdams - Details	5/5
15	Cofferdam Excavations - Plans and Sections	5/6
16	Massena Weir - Plan and Sections	5/7

Sheet No.	Title	File No.
	EXCAVATION	
17	Excavation Plan and Sections	BD-1-10/1
	MASONRY	
18	General Construction Scheme - Monolith Joints and Stages	BD-1-15/1
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20	Galleries	15/3
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22	South Bulkhead - Plan and Sections	15/5
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24	Guard Houses and Parapet Rails	15/7
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25	Abutment and Wing Dams	BD-1-20/1
26	Wing Dams and Dike	20/2
	SPILLWAY BRIDGE	
27	Spillway Bridge Details	BD-1-25/1
	DIVERSION GATES	
28	Diversion Gates and Operation	BD-1-30/1
	VERTICAL LIFT GATES	
29	Spillway Gates - Assembly	BD-1-40/1
30	Spillway Gates - Lifting and Coupling Arrangement	40/2
31	Spillway Gates - Towers, Guides and Sills	40/3
32	Spillway Gates - Fixed Hoists	40/4
33	Spillway Gates - Lifting Beams	40/5
34	Spillway Gantry Cranes	40/6
	TEMPORARY CONSTRUCTION	
35	Field Office - Plans, Elevations and Details	BD-1-160/1
36	Field Office - Utilities	160/2
	ELECTRICAL	
37	Electrical System - General Distribution Diagram	BD-1-180/1
38	Electrical System - North Bulkhead	180/2
	ROADS AND RAILROADS	
39	Typical Highway and Railroad Sections	BD-1-185/1

(b) These drawings show the work with as much detail as is possible in the present stage of development of the design. The work shall conform also to such other drawings and addenda relating thereto as may be published and/or exhibited in the office of the contracting officer prior to the opening of proposals, and to such drawings in explanation of details as may be required from time to time during construction, including such modifications as the contracting officer may consider necessary on account of conditions that are found to exist during the prosecution of the work. Detail bar lists and bending schedules for steel reinforcement will be furnished by the United States.

(c) Prior to the execution of the work the contractor shall check all drawings and shall immediately report to the contracting officer any errors or omissions discovered therein. Errors and/or omissions in drawings will not relieve the contractor of his responsibility for the correct fitting together and exact position of all parts of the work in accordance with the specifications. Parts and details not fully indicated on the drawings shall be detailed by the contractor in accordance with the best practice, or as directed by the contracting officer.

(d) The contractor shll submit fabricator's shop drawings of all structural steel and other metal work for approval. He shall also submit such shop drawings and material lists of all mechanical and electrical equipment as may be required by the contracting officer. No material shall be furnished or work done thereon prior to approval of these drawings. The contractor shall submit three (3) prints of each of such detailed drawings to the contracting officer who will return one print with his approval or notations of such changes as he finds necessary. Each print submitted for approval shall have in the lower right-hand corner just above the title a white space 3 inches by 4 inches in size in which the contracting officer will indicate the action taken. After approval, the contractor shall furnish the contracting officer one tracing and five prints of each approved drawings. Three copies or sets of parts catalogs, spare parts lists and operating instructions shall be furnished as specified above or as requested by the contracting officer. Payment for the contractor's drawings, including revisions thereof, parts catalogs, spare parts lists and operating instructions shall be included in the contract prices paid for material or work. All of these items will form a part of the contract when approved by the contracting officer.

(e) Ten sets of prints of necessary contract drawings (one-half size reproductions, or full size if desire) and twenty sets of specifications will be furnished the contractor without charge. Additional prints may be secured upon request at the cost of reproduction.

1-05. QUANTITIES. - The following estimate of quantities of work to be performed, as also shown in the "Schedule of Bid Items" under these specifications, is given only to serve as a basis for canvassing bids and for determining the approximate amount of the consideration of the contract. Unless the contract is terminated by the failure of Congress to appropriate additional funds (see paragraph 1-08), the contractor will be required to complete the work specified in paragraph 1-02 hereof, be the required quantities more or less than the amounts shown.

Item No:	Designation	Unit	Quantity
1	Excavation; Crib Footing	Cu.Yd.	65,900
2	Timber Cribs	M.B.M.	5,200
3	Crib Sheathing (Bulkhead)	Sq.Ft.	13,800
4	Steel Sheet Piling	Sq.Ft.	44,200
5	Crib Fill	Cu.Yd.	118,200
6	Earth Fill; Cofferdams	Cu.Yd.	310,000
7	Rock Fill; Cofferdams	Cu.Yd.	26,500
8	Riprap; Cofferdams	Cu.Yd.	15,700

Items No.	Designation	Unit	Quantity
9	Derrick Stone; Cofferdams	Ton	5,000
10	Cofferdam Removal	Cu.Yd.	376,800
11	Unwatering Cofferdam	Acre Ft.	56,000
12	Excavation; Diversion Cuts, Earth	Cu.Yd.	3,310,000
13	Excavation; Diversion Cuts, Rock	Cu.Yd.	5,000
14	Fill; Massena Weir, Rock	Cu.Yd.	6,500
15	Excavation; Massena Weir	Cu.Yd.	35,000
16	Stop Logs; Concrete	Cu.Yd.	1,180
17	Diversion Gates; Operation and Maintenance	Sum	Job
18	Excavation; Common	Cu.Yd.	490,000
19	Excavation; Rock	Cu.Yd.	80,000
20	Excavation; Borrow	Cu.Yd.	180,000
21	Line Drilling	Sq.Ft.	45,000
22	Drilling 3-inch Exploratory Holes	Lin. Ft.	17,400
23	Drilling 6-inch Holes	Lin.Ft.	7,500
24	Drilling 6-inch Concrete Cores	Lin.Ft.	1,000
25	Drilling Foundation Grout Holes in Rock	Lin.Ft.	64,000
26	Drilling Foundation Grout Holes in Concrete	Lin.Ft.	5,000
27	Pressure Grouting	Cu.Ft.	40,000
28	Core Boxes	Each	930
29	Excavation; Railroad and Highway	Cu.Yd.	130,000
30	Fill; Railroad and Highway	Cu.Yd.	175,000
31	Earth Fill; Compacted	Cu.Yd.	280,000
32	Additional Compaction	Square (100sf)	100,000
33	Filter	Cu.Yd.	16,700
34	Riprap, Dumped; Class A	Cu.Yd.	12,400
35	Riprap, Dumped; Class B	Cu.Yd.	22,400
36	Sand and Gravel Backing	Cu.Yd.	6,600
37	Road Surfacing	Sq.Yd.	66,000
38	Seeded Top Soil	Acre	6
39	Seeding	Acre	4
40	Concrete; Class A	Cu.Yd.	17,500
41	Concrete; Class B	Cu.Yd.	41,000
42	Concrete; Class C	Cu.Yd.	525,000
43	Rock Flour in Grout	Cu.Ft.	2,000
44	Sand in Grout	Cu.Ft.	2,000
45	Drains; Porous Concrete	Lin.Ft.	31,300
46	Special Bituminous Filler; Type C	Cu.Ft.	1,700
47	Steel Erection; Structural	Lbs.	7,500,000
48	Steel Erection; Concrete Reinforcing	Lbs.	5,000,000
49	Steel Rails; Placing	Lbs.	781,000
50	Spillway Gates; Erection	Lbs.	14,605,000
51	Gantry Cranes and Fixed Hoist; Erection	Sum	Job
52	Steel Forgings; Miscellaneous	Lbs.	2,500
53	Steel;Structural, Miscellaneous	Lbs.	5,000
54	Iron; Cast	Lbs.	40,000
55	Pipe; Cast Iron	Lbs.	38,000
56	Pipe; Wrought Iron	Lbs.	37,000

Items No.	Designation	Unit	Quantity
57	Pipe; Black Steel 8 inches	Lbs.	65,300
58	Pipe; Black Steel Miscellaneous	Lbs.	2,000
59	Pipe; Concrete, Halved	Lin.Ft.	5,600
60	Culverts 24"	Lin.Ft.	575
61	Culverts 36"	Lin.Ft.	600
62	Babbitt	Lbs.	46,000
63	Bronze; Castings	Lbs.	3,400
64	Copper; Sheet	Lbs.	930
65	Corrugated Iron; Water Stops	Lbs.	73,000
66	Doors & Windows; Steel	Lbs.	4,600
67	Highway Guard Rail	Lin.Ft.	29,000
68	Handrailing; Steel Pipe 2"	Lin.Ft	6,300
69	Handrailing; Steel Pipe 1½"	Lin.Ft	600
70	Floor Grating; Steel	Lbs.	55,000
71	Safety Treads	Lbs.	8,300
72	Scuttles	Each	2
73	Roof Ventilators	Each	6
74	Flagpole	Each	6
75	Glass Brick	Sq.Ft.	440
76	Conduit; Metal	Lbs.	30,000
77	Electrical Grounding System	Sum	Job
78	Bubbler Pipes	Each	120
79	Gallery Drains	Each	9
80	Roof Drains	Each	6
81	Roof Surfacing	Squares (100sf)	8
82	Rolled Gravel Surface	Sq.Yd.	15,300
83	Flagstone Steps	Sq.Yd.	50
84	Stone Fall	Cu.Yd.	120
85	Gravel	Cu.Yd.	35,000
86	Ballast	Cu.Yd.	11,700
87	Cross Ties	Each	11,000
88	Track Laying	Tracks (Ft.)	19,600
89	Field Office	Sum	Job
90	Field Office Extension	Sum	Job

1-06. COMMENCEMENT, PROSECUTION AND COMPLETION.

(a) The contractor will be required to commence work under the contract within ten (10) calendar days after the date of receipt by him of notice to proceed, to prosecute the said work with faithfulness and energy, and to complete the entire work within 1200 calender days after said date of receipt by him of notice to proceed, plus any extensions of time duly granted under the provisions of the contract and specifications. The work shall be prosecuted as vigorously as practicable during all seasons of the year.

(b) (1) The schedule of work on this contract will correlate with the schedule of work by other construction contracts, particularly those for the powerhouses. The contractor shall not start raising the pool until _____ days after receiving notice to proceed. The contractor shall complete raising the pool to Elevation 230 within _____ days after receiving notice to proceed. Should progress on the other construction contracts be delayed so that the contractor is prevented from raising the pool because of such delay, he shall be paid by the Government $750 a day for each calender day of delay and shall be given an extension of time on raising the pool and

final completion equal to the number of days of delay.

(2) In case of failure on the part of the contractor to raise the pool to Elevation 230 within the time thus determined and agreed upon, the contractor shall pay to the Government as liquidated damages the sum of $1000 a day for each calendar day of delay until the pool is raised to this elevation.

(3) In case of failure on the part of the contractor to complete the entire work within the time thus determined and agreed upon for its completion, the contractor shall pay to the Government as liquidated damages the sum of $500 for each calendar day of delay until construction is completed and the dam is placed in operating condition as determined by the contracting officer.

(4) Should the construction be completed and placed in operating condition except for minor finishing work as determined by the contracting officer, the contracting officer may conditionally accept and occupy the work; and thereafter the contractor shall pay to the Government, as liquidated damages the sum of $25.00 for each calendar day of delay until all the items and minor finishing work have been completed and accepted.

(5) In the event the entire structure has been completed and accepted and all work under the contract has been completed except for removal of contractor's plant and buildings and restoration of the site, no further liquidated damages will be assessed, but final payment will not be made until this latter work has been accomplished as required.

(c) If the completion of the undertaking to be performed under the terms of this contract be delayed by reason of delay in the delivery of materials or supplies essential to such performance because of national defense priorities and without the fault or negligence of the contractor, the time of performance will be extended for a period equal to such delay, as determined by the contracting officer, and subject to appeal, as provided in Article 9 of the contract.

1-07. SUNDAYS, HOLIDAYS AND NIGHTS. - Work on Sundays, holidays, and nights will be at the option of the contractor. However, when the contractor elects to work at such times, notice of his intention to do so shall be given the contracting officer within a reasonable time in advance thereof.

1-08. PAYMENTS.

(a) (Availability of Funds?)

(b) Payments will be made monthly on estimates of work performed in accordance with the contract and not included in any prior estimate, except that ten percent (10 %) of the amount of each estimate will be retained until the total amount retained is _____ dollars (_____), and this amount will be retained until it equals ten percent (10%) of the remaining work to be done. Thereafter with each monthly payment there will be paid such portion of the amount so retained as is in excess of ten percent (10%) of the work remaining to be done until the amount retained is reduced to _____ dollars (_____), which amount will be retained until the completion of the contract when final payment will be made.

1-09. WORK COVERED BY CONTRACT PRICE.

(a) The contractor shall, under his contract prices, furnish

and pay for all materials (except as specified in paragraph 1-10), labor and equipment for all permanent, temporary, preparatory and incidental work, furnish all accessories and do everything which may be necessary to carry out the contract in good faith, which contemplates everything completed in good working order, of good material and with accurate workmanship, skillfully fitted and properly connected and put together.

1-10. MATERIALS FURNISHED BY THE UNITED STATES.

(a) The following material furnished by the United States will be delivered to the contractor f.o.b., at the site of the work.

(1) Cement and Concrete Aggregates
(2) Reinforcements
(3) Diversion Gates and Appurtenances
(4) Spillway Gates, Gantry Cranes, Fixed Hoists, and Appurtenances
(5) Structural Steel
(6) Rails for Gantry and Permanent Railroad
(7) Cofferdam and Trestle Timber with Drift Pins, Bolts, Washers, and Tie Rods for Same.

The Government will at all times expedite the delivery of all orders but the Government will not be liable for any expense or delay caused the contractor by delayed deliveries except as provided for under Article 9 of the contract. The contractor shall be responsible that all railroad cars are unloaded promptly and will be held liable for any demurrage charges due to his failure to do so. He will be required to unload, deliver to site, store, clean, assemble, install, and paint this equipment and materials in accordance with these specifications, and the contract drawings.

(b) All materials and equipment shall be adequately housed or otherwise protected against deterioration and damage. When material stored at the side is not adequately protected by the contractor, such material will be kept protected by the contracting officer at the expense of the contractor. Any materials furnished by the Government which are damaged or broken by the contractor during the unloading, storing, or transporting of such materials, or in the prosecution of the work, shall be replaced by the contractor at his expense.

(c) The contractor shall check the quantity and condition of all materials delivered to him at the time of unloading, and in case there is damage to, or shortage of materials, he shall report it to the contracting officer in writing within 24 hours after delivery. If there is any shortage, or damage which in the opinion of the contracting officer is sufficient to cause the materials to be unfit for use in the work, and the shortage or damage has not been reported as specified above, the contractor will be charged with the actual cost of replacement of such shortage or damage.

(d) Cement and Aggregates for Concrete. - The Government will furnish all cement, fine aggregate, and coarse aggregate required for the work covered by these specifications. All cement furnished for concrete except high early strength cement, will be a moderate-heat-of-hardening Portland cement. All aggregates furnished (see Section V) will be either natural or manufactured sand, and gravel or crushed rock. Explorations and investigations are being conducted by the contracting officer for concrete aggregates. The results of these investigations will be made available to interested bidders at the U. S. Engineer Office, Massena, N. Y., and bidders may also, by request,

obtain a copy of the Government specifications for the concrete aggregates to be furnished.

(e) Cement and aggregates will be made available to the contractor at any time later than 90 days after the date of notice to proceed, and he shall give the Government at least 90 days notice in advance of the time he will require the first material. Thereafter he shall at all times keep the contracting officer informed of his anticipated requirements by submitting, ten days before the first of each month, or at such other times as may be directed by the contracting officer, a written notice of his future cement and aggregate requirements for the next 30 days. Copies of all orders for cement will be furnished promptly to the contractor. The cement will be furnished in bulk except that necessary for grouting and finishing work, which will be furnished in paper bags. Any cement, bulk or bag, which shall be damaged after delivery to the contractor shall be paid for by him. An difference in excess of one-half of one percent between the net quantity of bulk cement and aggregates delivered to the contractor, and the quantity of the above materials incorporated in the completed and accepted work will be charged to the contractor, at its cost to the Government at the point of delivery to the contractor. The quantity of bulk cement and aggregates delivered to the contractor will be determined by certified shipping weights. The contractor shall provide, at the site, a minumum storage for 20,000 barrels of bulk cement and 500 barrels of bag cement, and shall be prepared to receive and stock pile a minimum of 100,000 tons of concrete aggregate. In order that cement will not become unduly aged after delivery, the contractor shall not use cement in the work directly from the freighting or transporting operations whenever any cement is available that has been stored more than 60 days after delivery to the contractor. Cement that has been stored for more than 90 days shall be retested at the expense of the contractor. (See paragraph 1-31(d).) Storage bins for cement shall be so constructed that there will be no dead storage and will provide adequate protection against the elements.

(f) Cement and aggregates furnished by the Government may be used by the contractor in erecting construction plants and facilities. The contractor will be billed for the actual cost to the Government at the point of delivery for furnishing the materials so used by the contractor. The materials thus used shall not be included in the one-half of one percent tolerance specified above.

(g) The contractor shall be responsible for unloading and handling of all cement and aggregates furnished by the Government. The cost of such unloading, storing or stock piling shall be included in the contract unit prices for those items on which the material will be used.

(h) The contractor shall return to the Government, f.o.b. in cars at the point of delivery, all cement furnished by the Government and not used. The contractor will charged for any cement, not used and not returned, except for one-half of one percent allowed for loss, an amount equal to the cost to the Government at the point of delivery to the contractor.

Reinforcement

(i) REINFORCEMENT. - Reinforcement will be cut to length and

bent before delivery. See paragraph 5-14, for specified placing requirements.

(j) Reinforcement will be made available to the contractor within 150 days after the contractor notifies the Government he will require such reinforcement, and he shall furnish written notice of his requirements for the first four months. Thereafter he shall at all times keep the contracting officer informed of his anticipated requirements for reinforcement in the following manner; On the first day of the first 4-month period the contractor shall furnish written notice of his future requirements during the second 4-month period, and so on through the duration of the contract. Upon receiving notice to proceed, the contractor shall also furnish the contracting officer a general schedule of reinforcement requirements for the duration of the contract by four-month periods, it being understood that shipments may be based on definite requirements as stated in the contractor's regular periodic notices of requirements.

(k) Copies of all orders for concrete reinforcements will be furnished promptly to the contractor. Any reinforcement which shall be damaged after delivery to the contractor, and any difference in excess of one-half of one percent between the net quantity of reinforcement delivered to the contractor and the quantity incorporated in the completed and accepted work will be charged to the contractor, at its cost to the Government at the point of delivery to the contractor. The quantity of reinforcement delivered to the contractor will be determined by certified shipping weights.

(l) Diversion gates, spillway gates, structural steel, gantry cranes, fixed hoists, and appurtenances (see Section VII and VIII) will be made available for erection by the contractor. The contractor shall furnish written notice and schedule of his requirements for the diversion gates, spillway gates, structural steel, gantry cranes, hoists, and appurtenances, at least 150 days before the time proposed for starting erection.

(m) Rails for the gantry cranes, railroad and appurtenances (see Sections VIII and XIII), timber for cofferdams and trestle, drift pins, bolts, washers, and tie rods (see Sections II and XIII) will be made available for erection by the contractor. On receiving notice to proceed he shall within 10 days furnish written notice of his first requirements. Thereafter the contractor, within 30 days after he receives notice to proceed shall furnish written notice and schedule of his requirements for the duration of placing the above items.

1-11. ELECTRICAL ENERGY DURING THE CONSTRUCTION PERIOD.

(a) The United States will provide a source of electrical energy without cost to the contractor at a point approximately 500 feet from the south abutment. The capacity of this source will be 5,500 K.V.A. at 6,600 volts, 3-phase, 60 cycle. The contractor, if he elects to use this power, shall provide, without cost to the United States, all facilities and equipment necessary to furnish himself with electrical energy for power and lighting from the above source. This shall include a meter, metering equipment, transformers, poles, switches, lights, and any other equipment that may be necessary. The contractor will be required to light during the construction period all highways built by him, and all job roads, galleries within the dam, outside work areas, all safety lights (see paragraph 1-22), and any other lighting as directed, all to the satisfaction of the contracting officer.

Energy will be 3-phase, 60-cycle, for the operation of all permanent government equipment, and shall be furnished at the voltages as required for each specific use or as indicated on the drawings. The contractor shall maintain service until completion of the contract. All costs for electrical energy shall be borne by the contractor. The contractor shall make payment to the United States each month for electrical energy furnished him, at the rate of the actual cost to the United States, plus 10 percent to cover installation and overhead, for supplying the electrical energy. The rate of the actual cost to the United States may be obtained at the U. S. Engineer Office, Massena, New York.

(b) The contractor shall provide for the period of this contract the electrical energy for lighting and miscellaneous use in the government field office (Section XII). The contractor shall provide an electric meter in the field office, and each month the electrical energy furnished the field office will be deducted from the total electrical energy furnished the contractor. The energy required in the field office shal be 220/110-volt, 60-cycle, single-phase, 3 wires.

1-12. ORDER OF WORK. - The following general program of work is contemplated, subject to such modification as may be found necessary or desirable by the contracting officer. Should the contractor desire at the time of making his proposal to change this general program other than dates of beginning, raising pool to Elevation 230, and completion, he shall so state in his proposal. The main features of the work are as follows:

(a) First Stage: Will include the construction of the south portion of the dam except for diversion openings.

(b) Second Stage: Will include the construction of the north portion of the dam except for diversion openings if required.

(c) Third Stage: Will include closure of diversion openings and completing construction. Further description of the work to be performed during these stages is given in Section II.

(d) Concurrently with any of the foregoing operations the contractor may also carry on any other operations that do not, in the opinion of the contracting officer, impair safety, nor in any way adversely affect the work, nor divert force, equipment, or material that should be contributing to the progress of operations of higher priority.

(e) The contractor shall at all times keep the contracting officer informed of the order of proposed operations. To this end, in addition to the charts required to be submitted in accordance with paragraph 16 (d) of the Invitation for Bids, the contractor shall furnish such supplementary charts and/or other information regarding proposed future operations as may be required by the contracting officer.

1-13. RIGHT-OF-WAY. - The right-of-way for the work covered by these specifications and for the access railroad and highway will be furnished by the Government.

1-14. ROADS AND GROUNDS.

(a) The contractor shall have the privilege of using the Government-controlled land within the work areas shown on Sheet No.2 of the drawings, except for that part of said lands as may be reserved by the contracting officer for other purposes.

(b) At any time during the progress of the work the contractor shall, when so directed by the contracting officer, promptly vacate and clean up, within 60 days after written notice, without expense to the Government, any part of the grounds which have been in use by him when such grounds are needed for other purposes. The contractor shall keep the buildings and grounds in use by him at the site of the work in an orderly and sanitary condition and shall provide suitable extinguishers or other fire-fighting apparatus for ready use in all buildings erected or in use by the contractor on Government property.

(c) The contractor shall not obstruct any existing roads on the lands controlled by the United States and Shall maintain all roads in the vicinity of the work in as good condition as exists at the time of commencement of the work.

(d) The contractor will be required to construct a covered wooden observation platform having an area of about six-hundred (600) square feet for the use of the general public. This platform shall be constructed at a location selected by the contracting officer. The contractor shall also provide suitable and safe access to the observation platform for the general public so that it may observe the work in progress. No separate payment will be made for this work.

1-15. CAMP CONSTRUCTION AND SUPERVISION.

(a) The construction, operation and maintenance of facilities for the quartering and subsisting of the contractor's employees will be subject to the approval of the contracting officer if the facilities are located on Government property. The contractor will be permitted to construct such facilities on the right-of-way owned by the Government only at such locations specifically approved by the contracting officer. The type of construction and design for the building erected by the contractor will be subject to the approval of the contracting officer. Expensive or permanent types of construction will not be required, but no unsightly, unsanitary shacks or shanties will be permitted. The contractor will be required to comply with State and local laws relative to police and sanitary measures and with other protective measures imposed by the contracting officer in the administration of his camps. In the event of noncompliance with such laws and regulations, the contracting officer will enforce them at the expense of the contractor. The contracting officer may require the contractor to discharge any employee from the work for violation of camp regulations. (See paragraph 1-21(c).)

(b) In the event the contractor makes arrangements with landowners, other than the Government, near the site of the work for the construction of temporary facilities for the quartering and subsisting of his employees, he will be subject, in the operation and maintenance of such a camp, to all the provisions of subparagraph (a) above with respect to the requirements for compliance with all State and local laws relative to police and sanitary measures, and with measures such as safety, fire hazard and protection, etc., imposed by the contracting

officer. In the event of noncompliance with such laws and regulations while operating and maintaining a temporary camp not on the Government-owned or controlled property, the contracting officer will enforce them at the expense of the contractor. The contracting officer may require the contractor to discharge from the work any employee for violation of camp regulations, notwithstanding the fact that the camp may not be located on Government-owned or controlled property.

(c) In the event the contractor provides subsistence for his employees, he shall also provide subsistence to such Government employees as may require such accommodations and at the same rates charged his own employees.

(d) No business or recreational facilities shall be established or operated on Government-owned or controlled lands without the written approval of the contracting officer.

1-16. BORROW PITS.

(a) Should the contractor locate deposits of bank run sand and gravel or other materials within the Government-controlled area in the reservoir or adjacent to the site, which are satisfactory to the contracting officer, he may, on approval of the contracting office use such deposits. No charge with be made to the contractor for materials authorized to be taken from Government-controlled lands and used in the work covered by these specifications. All borrow pits shall be left in a neat and sightly condition, and all pits above the normal ground water table shall be adequately drained. Side slopes shall be not steeper than 1 on 3. No separate payment will be made for such work.

(b) Approval of material sources by the contracting officer shall not constitute approval of all materials taken from such deposit and the contractor will be responsible for the quality of all material used in the work.

(c) Should the contractor obtain materials from deposits on private lands he shall pay any royalties or other charges required, and the contracting officer assumes no responsibility for such use, and the Government will not be obligated in any way.

1-17. DATUM AND REFERENCE BENCH MARKS. - The plane of reference used in these specifications and on the drawings is Mean Sea Level. Elevations referring to this datum plane are to be determined from the following bench mark: See Bulletin 514, Results of Spirit Leveling in New York. U. S. Geological Survey, page 59.

Pollys Creek, 420 feet east of, 5.5 feet from south fence of road, on south side of river road on line of a stone fence running north and south, opposite barnyard of Frank Polly's farm; top of roundheaded brass bolt set in concrete base (U.S. Corps of Engineers 4). Elevation 221.378.

1-18. PHYSICAL DATA.

(a) Foundation data. - Investigations, including surveys, borings, test trenches, pits and test shafts made at the site by the United States to determine the character of the foundation materials are shown on the drawings referred to in paragraph 1-04.

The United States does not guarantee that other materials will not be encountered nor that the proportions of the several materials will not vary from those indicated by the explorations. Bidders are expected to examine the site of the work, the logs of borings, test pits, probings, and the cores and samples which are available at the U. S. Engineer Office, Massena, New York, and, after investigation, decide for themselves the character of the materials and make their bids accordingly.

(b) Weather Conditions. - Meteorological data in the form of rainfall, snow and temperature records, prepared from records covering a period of 33 years (1907 to 1939, inclusive) of the U. S. Weather Bureau Station at Canton, New York, approximately 35 miles southwest of the site of the work, are as follows:

	Temperature Degrees Fahrenheit		Precipitation (Mean Monthly)	
Month	Mean Monthly	Extreme Max.	Extreme Min.	Total Inches	Inches of Snow
January	16.8	61	-41	2.64	14.9
February	15.8	63	-43	2.30	15.5
March	27.9	78	-30	2.60	13.1
April	41.7	85	-1	2.59	4.9
May	54.2	93	21	3.03	0.2
June	63.5	97	30	3.51	0
July	68.8	99	34	3.62	0
August	66.5	96	35	3.42	0
September	58.8	91	25	3.44	0.1
October	47.4	83	14	3.04	1.0
November	35.0	75	-15	3.02	7.5
December	21.4	61	-37	2.62	14.5

(c) St. Lawrence River Water Temperature. - The St. Lawrence River water temperatures prepared from records covering a period of 8 years (1933 to 1940, inclusive) of the City Engineer, Ogdensburg, New York, are as follows:

	Water Temperature Degrees Fahrenheit		
Month	Mean Monthly	Extreme Max.	Extreme Min.
January	32.7	36	32
February	32.9	37	32
March	33.0	37	32
April	36.2	46	32
May	46.9	60	37
June	58.8	66	49
July	65.5	73	59
August	70.5	74	63
September	64.6	72	59
October	56.4	65	50
November	46.5	52	37
December	35.7	44	32

The above data are included for the information of the contractor. The

Government assumes no responsibility for their completeness or accuracy or for deductions, interpretations, or conclusions drawn therefrom.

(d) River Stages.- Mean low water of the St. Lawrence River at the foot of Long Sault Island is at Elevation 169.6. During the period of record of winter water surface elevations, 1913 to 1940, inclusive, the maximum stage occuring at this point during the winter months of December - March, inclusive, is estimated to have been Elevation 196.2 (Jan. 1918). Winter stages frequently have reached levels between El. 175 and El. 190. Such high stages are produced by ice conditions in the river downstream from the site of the work and are not expected to occur during the period April 16 to Nov. 30. The maximum stage occurring at the aforementioned location from 1888 to 1940 inclusive during the period April 16 to Nov. 30, is estimated to have reached approximate Elevation 174.6. Additional data on river stages are available for inspection in the U. S. Engineer Office Massena, N. Y. The Government does not guarantee the completeness or accuracy of any of the above data and assumes no responsibility for deductions, interpretations, or conclusions drawn therefrom.

(e) Utilities. - In the event that power lines, telephone or telegraph lines, pipe lines, cables, or other utilities are encountered within the limits of the work including the access right-of-way, the contractor shall notify the contracting officer in writing of any necessary changes in such utilites not less than 30 days in advance of the date he desires such changes made. The contracting officer will arrange for the relocation or reconstruction of such utilities by other agencies, or will authorize the contractor to remove them, at no extra cost to the Government, to the extent required for execution of the contract work.

1-19. TRANSPORTATION FACILITIES. -The following data on transportation facilities is furnished for the information of the contractor but the Government assumes no responsibility for its completeness or accuracy and the contractor is expected to investigate the conditions and determine for himself the probable transportation facilities available.

(a) Railroads. - Massena, N. Y. is served by the New York Central Railroad and a branch line of the Canadian National Railway (known as the Grand Trunk Lines in the United States). Plans are now being developed for a construction railroad to be built by others, such railroad to connect with existing lines. The contemplated railroad will cross the Grass River or the Massena Power Canal, and will probably terminate a few miles northest of Massena, N. Y. The contractor shall construct the access railroad from the above line at a point indicated on the drawings (also see Section XIII), to the site of the Long Sault Dam.

(b) Highways. - The town of Massena, N. Y. is served by New York State Highways No. 37 and No. 56, the latter connecting with U. S. Highway No. 11 at Potsdam, N. Y., about 25 miles distant. Several improved county roads connect the aforementioned State Highways with the site of the work.

(c) Water. - The nearest port to the site of the work providing docking and other harbor facilities is Cornwall, Ontario, Canada. Cornwall is accessible by water from Lake Ontario and from the head of deep-water navigation at Montreal by means of the St. Lawrence Canals and open-river stretches of navigable channels. Locks in the canals generally limit the size of craft to widths less than 45 feet, lengths less than 250 feet, and drafts less than 14 feet.

For a detailed description of the existing canal and lock clearances and depths, the contractor is referred to the booklet "The Canals of Canada", published by the Department of Transport, Ottawa, Ontario, Canada, copies of which are available for inspection in the U. S. Engineer Office, Massena, N. Y. The navigation season is usually limited by ice conditions to the period from April 20 to December 1.

1-20. ORGANIZATION, PLANT AND PROGRESS.

(a) The contractor shall perform, directly and without subcontracting, not less than fifty percent (50%) of the work, to be calculated on the basis of the contract price.

(b) The contractor shall employ an ample force of properly experienced men and provide a construction plant properly adapted to the work and of sufficient capacity and efficiency to accomplish the work in a safe and workmanlike manner at the rate of progress specified in his bid. All plant shall be maintained in good working order and provision shall be made for immediate emergency repairs. No reduction in the capacity of the plant employed on the work shall be made except by written permission of the contracting officer. The measure of the "capacity of the plant" shall be its actual performance on the work to which these specifications apply. It is understood that award of this contract shall not be construed as a guaranty by the United States that plant listed in statement of contractor for use on this contract is adequate for the performance of the work.

(c) Should the contractor fail to maintain the rate of progress proposed in his bid, the contracting officer may require that additional men or plant, or both, be placed on the work, working if necessary during additional periods, or a reorganization of plant layout be effected in order that work be brought up to schedule and maintained there. Should the contractor refuse or neglect so to increase the number of men or plant, or both, or to reorganize the plant layout in the manner satisfactory to the contracting officer, the latter may proceed under the provisions of Article 9 of the contract.

1-21. LIABILITY AND SAFETY REQUIREMENTS.

(a) Accident Prevention. - In order to protect the life and health of employees in the performance of this contract, the contractor will comply with all pertinent provisions of the "Safety Requirements in Excavation - Building - Construction" Approved by the Chief of Engineers, December 16, 1941, (a copy of which is on file in the office of the contracting officer) and as may be amended, and will take or cause to be taken such additional measures as the contracting officer may determine to be reasonably necessary for this purpose. The contractor will maintain an accurate record of and will report to the contracting officer in the manner and on the forms prescribed by the contracting officer, all cases of death, occupational disease and traumatic injury arising out of or in the course of employment on work under this contract. The contracting officer will notify the contractor of any non-compliance with the foregoing provisions and the action to be taken. The contractor shall, after receipt of such notice, immediately correct the conditions to which attention has been directed. Such notice, when served on the contractor or his representative at the site of the work, shall be deemed sufficient for the purpose aforesaid. If the contractor fails or refuses to comply promptly, the contracting officer may issue an order stopping all or any part of the work. When satisfactory corrective action is taken, a start order will be issued. No part of the time lost due

to any such stop order shall be made the subject of claim for extension of time or for excess costs or damages by the contractor.

(b) The contractor will not be allowed to block or obstruct any public highway without having secured prior permission from the contracting officer, and he shall provide safe, temporary detours. During the time the public highways may be so blocked, the contractor shall place danger lights, barricades and warning signs in accordance with the laws of the State of New York.

(c) The contractor shall be responsible that his employees strictly observe the laws of the United States affecting all opertions at the site under the contract. He shall comply with all applicable Federal, State and local laws, including those concerning the inspection of boilers and other equipment, the licensing of engineers and other employees.

(d) The United States will not be responsible for any damage to or increased difficulties in performance of the work under this contract on account of any scour or other changes in the river bed or banks or water currents resulting from other construction at the site, and no payments, allowances or deductions will be made for or on account of any such damage or difficulties.

(e) Nothing in this paragraph shall be construed as modifying the responsibility of the contractor as set forth in Article 10 of the contract.

1-22. LIGHTS. - The contractor shall, at his own expense, display proper lights continuously each night, between the hours of sunset and sunrise and during fogs, upon cofferdams, all floating plant connected with the work, and all ranges and other stakes in connection with it, when necessary in the opinion of the contracting officer, and shall be responsible for all damages resulting from any neglect or failure in this respect. If work is done at night the contractor shall maintain, from sunset to sunrise, such lights on or about his plant as the contracting officer may deem necessary for the proper observation of the operations.

1-23. USE OF EXPLOSIVES. - The contractor shall use the utmost care in the use of explosives necessary for the prosecution of the work, not to endanger life or property. All blasting operations shall be conducted by experienced men only. The handling and use of explosives shall be done strictly in accordance with the latest methods and rulings to insure safety, in accordance with the specifications issued by the U. S. Bureau of Mines, and in compliance with the local and State laws. Failure to observe necessary precautions will be sufficient grounds for temporary suspension of the work. All explosives shall be transported and stored in a secure manner, and in accordance with local and State laws; all vehicles and such storage places shall be marked clearly "DANGER - EXPLOSIVES," and shall be in the care of competent watchmen at all times. In no case shall caps or other detonators be stored or transported with dynamite or other explosives. The location of magazines for the storage of explosives and for the separate storage of detonators shall be subject to the approval of the contracting officer.

1-24. PROPERTY DAMAGE. -

(a) Damage to Government property or to the works due to failure of the contractor to carry out the terms of the contract and specifications, to take reasonable precautions, or to maintain progress to approved schedules, or to carry out the instructions of the contracting officer shall be made good by the contractor without expense to the United States. He will also be held responsible for

any damage done to adjoining property through his neglect or failure to take proper precautions (see Article 10 of the contract).

(b) The contractor will not be held responsible for damage sustained by the permanent work from accident, flood, or exposure where such damage is not due to his fault or negligence and where the work is being conducted in accordance with the terms and schedule of the contract and specifications, but he shall make such repairs as the contracting officer may direct to such damaged portions of the work, at the applicable contract unit prices for the various items of work.

1-25. INSPECTION.

(a) The work will be conducted under the general direction of the contracting officer and wil be inspected in accordance with Article 6 of the contract by inspectors appointed by him. The inspectors will keep a record of the work done and see that the location and limit marks are kept in proper order, but the presence of the inspector shall not relieve the contractor or his responsible agent (see Article 8 of the contract) of responsibility for the proper execution of the work.

(b) Should the contractor refuse, neglect or delay compliance with the requirements concerning facilities for inspection and layout (see paragraph 1-26), the specific facilities may be furnished and maintained by the contracting officer, and the cost thereof deducted from any amounts due or to become due the contractor.

(c) Except as specified in this paragraph, in Article 6 of the contract, and in paragraphs 1-31 (d) and 1-26, all expenses of inspection will be borne by the United States.

(d) The contractor shall furnish a suitable room containing at least 150 square feet of floor space, at his concrete mixing plant for a Government laboratory to be used for temporary storage of concrete cylinders, and determination of moisture content of the concrete aggregate. This room shall be protected from the weather, properly lighted, provided with necessary work tables and benches, and shall be heated if concrete work is done in cold weather. The location for this room shall be subject to the approval of the contracting officer. The contractor shall provide, during the construction period, electricity for light and miscellaneous uses, see paragraph 1-11 (b), and an adequate supply of water for drinking and sanitary purposes in the Government field offide, constructed in accordance with Section XII of these specifications.

(e) Portable Buildings. - The contractor shall furnish two suitable portable buildings, located as required by the contracting officer within the site of the work, for use by the Government. These buildings shall be approximately 10 feet by 12 feet and shall be supplied with an instrument rack, a built-indesk, clothes lockers, supply cabinet with lock, bench and such other appurtances as may be required by the contracting officer. The buildings may be of any type construction as approved by the contracting officer and shall be movable, as the contracting officer may require them to be shifted during progress of the work. They shall be reasonably weather proof, and shall be supplied with heat and electric lights without cost to the Government.

(f) It is understood that any instructions, or decisions given by a superior officer, through the contracting officer, are to

be considered instructions or decisions of the contracting officer, in all cases where, under the terms of this contract, decision rests with the contracting officer.

1-26. LINES, GRADES AND MEASUREMENTS.

(a) The work shall be carried out in strict accordance with lines, grades, and dimensions shown on the drawings or as directed from time to time by the contracting officer.

(b) The contractor shall, at his own expense, furnish all stakes, templates, patterns, platforms and special labor that may be required in setting and cutting, or laying out any part of the work.

(c) The contracting officer will furnish the control points, lines, grades, and elevations necessary to enable the contractor to perform the construction work. After this layout has been made by the contracting officer, it shall be the responsibility of the contractor to supply and maintain all additional survey points, grade stakes, form locations and other work lines necessary for the proper execution and conduct of the work. From time to time during the progress of the work, the contracting officer will check the contractor's lines and grades to determine whether or not the work is being accurately and properly executed, but such checks will in no way relieve the contractor of the responsibility for executing the work in accordance with the plans and specifications, and the field layout furnished by the contracting officer.

(d) Bench marks, triangulation stations, and principal control points shall be preserved by the contractor and in case of their destruction or removal by him or his employees, they will be replaced by the contracting officer at the contractor's expense.

1-27. CHANGES AND CHANGED CONDITIONS. - When changes are made in the specifications or drawings, or changed conditons are encountered during the progress of the work, which cause an increase or decrease in the amount due under the contract, or in the time required for its performance, an equitable adjustment shall be made in accordance with Articles 3 and 4 of the contract.

1-28. MINOR MODIFICATIONS. - The right is reserved to make such minor changes in the execution of the work to be done under these specifications as, in the judgment of the contracting officer, may be necessary or expedient to carry out the intent of the contract; provided, that the unit cost to the contractor of doing the work shall not be increased thereby, and no increase in unit price over the contract rate will pe paid to the contractor on account of such changes. (See Articles 3, 4, and 5 of the contract.)

1-29. CLAIMS, PROTESTS AND APPEALS.

(a) If the contractor considers any work demanded of him to be outside the requirements of the contract or if he considers any action or ruling of the contracting officer or of the inspectors to be unfair, the contractor shall without undue delay, upon such demand, action, or ruling, submit his protest thereto in writing to the contracting officer, stating clearly and in detail the basis of his objections. The contracting officer shall thereupon promptly investigate the complaint and furnish the contractor his decision,

in writing, thereon. If the contractor is not satisfied with the decision of the contracting officer, he may, within thirty days, appeal in writing to the Secretary of War, whose decision or that of his duly authorized representative shall be final and binding upon the parties to the contract. Except for such protests or objections as are made of record in the manner herein specified and within the time limit stated, the records, rulings, instructions or decisions of the contracting officer shall be final and conclusive.

(b) All appeals from decisions of the contracting officer authorized under the contract shall be addressed to the Secretary of War, Washington, D. C. The appeal shall contain all the facts or circumstances upon which the contractor bases his claim for relief and should be presented to the contracting officer for transmittal within the time provided therefor in the contract.

1-30. PATENTS. - The contractor shall hold and save the Government, its officers, agents, servants and employees, harmless from liability of any nature or kind, including costs and expenses for or on account of any patented or unpatented invention, article or appliance manufactured or used in the performance of this contract, including its use by the Government.

1-31. STANDARD TESTS, QUALITY AND GUARANTEES.

(a) All materials furnished by the contractor, supplies and parts, and assemblies thereof, entering into the work to be done under these specifications, shall be tested as specified herein, or if not specified, in conformity with Article 6 of the contract and according to the best modern approved methods for the particular type and class of work.

(b) Unless otherwise authorized or directed, where standard published specifications of recognized authorities or organizations are specified, the latest revision of such specifications current at the time the work is executed shall govern.

(c) Unless waived in writing by the contracting officer, all tests and trials shall be made in the presence of a duly authorized representative of the contracting officer. When the presence of the inspector is so waived, sworn statements, in triplicate, of the tests made and the results thereof, shall be furnished the contracting officer by the contractor as soon as possible after the tests are made.

(d) All costs of all tests and trials, excepting the expenses of the Government inspectors, shall be borne by the contractor and shall be included in the contract price, unless specified otherwise.

(e) In accordance with Article 7 of the contract, all materials, supplies and articles furnished and incorporated in the permanent structure shall be of the highest grade, free from defects and imperfections, of recent manufacture, and unused. Workmanship shall be of the highest grade and in accordance with best modern standard practice.

(f) All articles, supplies, equipment, parts and assemblies thereof, of standard manufacture, or for which detail design or requirements are not prescribed in these specifications shall be guaranteed by the contractor against any failure in proper use or operation, caused by defective material, workmanship or design, for a period of one year from the date of final acceptance

of the complete work under this contract. Failure in any part due to such causes within that time shall be promptly and satisfactorily remedied by the contractor without cost to the United States.

1-32. PROTECTION OF STORED MATERIALS. - All materials, supplies and articles delivered at the site shall be adequately housed or otherwise protected against deterioration and damage to the satisfaction of the contracting officer. When material stored at the site and partly paid for is not adequately protected by the contractor, such material will be kept protected by the contracting officer at the expense of the contractor, and no partial payments will be made upon future delivery of the articles or commodities in question.

1-33. MISPLACED MATERIAL. - Any material that is deposited elsewhere than place designated or approved by the contracting officer will not be paid for, and the contractor may be required to remove such material and waste it or redoposit it as directed.

1-34. STANDARD STOCK PRODUCTS.

(a) All materials, supplies and articles furnished shall, wherever so specified, and otherwise wherever practicable, be the standard stock products of recognized reputable manufacturers. The standard stock products of manufacturers other than those specified will be accepted when it is proved to the satisfaction of the contracting officer that they are equal in strength, durability, usefulness and convenience for the purpose intended (see Article 7 of the contract). Any changes required in the details and dimensions shown on the drawings for the substitution of standard stock products, other than those provided for, shall be properly made as approved by the contracting officer, and at the expense of the contractor. The references herein to brands and catalog numbers are intended to be descriptive and not restrictive, and are used only to indicate articles that will be satisfactory. Other makes and catalog numbers will be accepted provided that they are similar and equal to those specified herein or called for on the drawings.

(b) Data to be Submitted for Approval. In accordance with Article 7 of the contract, prior to the placing of any purchase order for products of standard manufacture, and sufficiently in advance of the proposed purchase date to enable the contracting office to determine whether the proposed product conforms to the specifications, the contractor shall submit for the approval of the contracting officer complete descriptive data in triplicate, consisting of dimensioned drawings, catalog references and specifications, typical performance records, and such other information as may be required to be submitted on special forms to be furnished by the contracting officer to identify clearly each product in question. The term "or equal" shall not be used in any descriptive information furnished. Except at the contractor's risk, no purchse order shall be placed for any product which has not been approved by the contracting officer.

(c) Final Completion Data. - There shall be supplied 5 complete sets of data, each separately bound in a leather binder, for each major item of equipment furnished and installed under this contract. These data shall consist of all necessary instruction

bulletins, complete drawings, complete parts and material lists positively identifying each part, manufacturer's recommendation as to spare parts, and all other necessary data.

1-35. PREFERENCE FOR DOMESTIC ARTICLES.

(a) With reference to article 18 of the contract, because the materials listed below, or the materials from which they are manufactured, are not mined, produced, or manufactured, as the case may be, in the United States in sufficient and reasonably available commercial quantities and of a satisfactory quality, their use in the work herein specified is authorized without regard to the country of origin:

Platinum	Nickel	Asbestos
Chromium	Rubber	China Wood Oil (Tung Oil)
Cork	Teak Wood	Balsa Wood
Jute	Silk	English Ball Clay
Kaurigum	Sisal	English China Clay
Lac	Tin	Natural Copper-Nickel
Asphalt	Aluminum	Alloy
		Diamonds

(b) Articles, materials or supplies manufactured in the United States and containing mercury, antimony, tungsten or mica of foreign origin may be used in the work herein specified because such manufactured articles, materials, or supplies have been manufactured in the United States substantially all from articles, materials, or supplies, mined, produced or manufactured, as the case may be, in the United States.

1-36. INTERFERENCE WITH OTHER CONTRACTORS. - Other contractors will perform work on the Long Sault Dam pertaining to installing and placing electrical and operating equipment. In addition other major work will be undertaken in the vicinity of the dam at approximately the same time, such as the Massena Canal Intake Works, Long Sault Canal, locks, and powerhouses. The contractor shall not interfere with materials, appliances or workmen of the United States or of any other contractor who may have work at this site. As far as practicable, all contractors shall have equal rights to the use of all roads, grounds, and adjacent river, and make equitable agreements among themselves for the use of temporary railroads and highways. In case of disagreement regarding such use, the decision of the contracting officer shall govern. (See Article 13 of the contract.)

1-37. RESTORATION OF SITE. - Before final payment is made, the contractor shall remove from the site, without expense to the United States, all rubbish and unused materials provided by him, temporary buildings, cofferdams and other structures erected by him, shall fill all holes or cavities made for his convenience, except as otherwise provided, and shall leave the whole site in good order and condition, all as required by the contracting officer.

1-38. WAGE AND LABOR PROVISIONS.

(a) Pursuant to the Provisions of Article 17 of revised United States Standard Form No. 23 the following wage rates have been determined by the Department of Labor:

SCHEDULE OF WAGE RATES

Classification	Minumum Rate per Hour
Blacksmith	
Blacksmith Helper	
Boilermaker	
Boilermaker Helper	
Bricklayer	
Bricklayer Tender	
Carpenter (Skilled)	
Carpenter, Apprentice, 1st year	
Carpenter, Apprentice, 2nd year	
Carpenter, Apprentice, 3d year	
Concrete Finisher (Rough concrete)	
Concrete Form Stripper	
Concreteman (Puddler, Screeder, Vibratorman & Curing)	
Conveyor Tender	
Dumpman (Spotter & Grademan)	
Electrician	
Electrician Helper	
Engineman (Stationary Power Plants)	
Fireman	
Glazier	
Hooktender (Concrete Placement)	
Laborer (Common)	
Machinist	
Machinist Helper	
Mason (Stone)	
Mechanic	
Mechanic Helper	
Millwright	
Motorman (Dinky)	
Oiler	
Operators of Power Equipment:	
Air Compressor (over 750 c.f.m.)	
Air Compressor (over c.f.m. and under)	
Air Hammer(Jackhammer, Pavement Breaker, etc.)	
Cement Pump	
Concrete Batching Plant	
Concrete Mixer	
Concrete Pump	
Core Drill	
Crane (except Gantry Crane)	
Derrick	
Dragline	
Elevating Grader	
Gantry Crane	
Grader (Finish)	
Grader (Rough)	
Grout Machine	
Hoist	
Launch Operator (150 H•P. or under)	
Pile Driver	
Power Saw	
Power Scraper	

SCHEDULE OF WAGE RATES (CONTINUED)

Classification	Minimum Rate per Hour
Pump (100 H.P. or over)	
Pump (under 100 H.P.)	
Screening Plant	
Shovel	
Tractor (under 35 H.P. without attachments)	
Tractor (35 H.P. and over, and all tractors with attachments)	
Painter	
Pile Drivermen, Leadsmen, Linesmen, Nozzlemen, Winchmen	
Pipe Fitter	
Pipe Fitter Helper	
Plasterer	
Plasterer Tender	
Plumber	
Plumber Helper	
Powderman	
Powderman Helper	
Reinforcing Steel Worker	
Rigger	
Roofer	
Sheetmetal Worker	
Signalman, Concrete Placement (Phone man)	
Structural Steel Worker	
Structural Steel Worker Helper	
Teamster (2 up)	
Teamster (4 up or more)	
Tool Dresser	
Truck Driver (under 4 tons)	
Truck Driver (4 tons to 10 tons)	
Truck Driver (over 10 tons)	
Welder (Certified - structural steel)	
Welder (Certified - other than structural steel)	
Welder's Helper	

(b) Each class of laborer and mechanic specified in the above schedule shall receive not less than the minimum rate of wages speified therein, except that deductions from wages paid may be made as required by any laws now or hereinafter in force, in the state in which this project is situated, calling for contributions by employees from earnings to funds maintained in the administrations of an unemployment compensation law under the Social Security Act. In the event that it becomes necessary to employ any laborer or mechanic whose work is not covered by any of the classifications in said schedule, he shall be paid not less than the prevailing rate of wages for the class of work done by him. Such rate shall be predetermined by the contracting officer. In case any dispute arises as to what are the prevailing rates of wages for work of a similar nature which cannot be adjusted by the contracting officer, the matter shall be referred to the Secretary of Labor for determination and his decision thereon shall be conclusive on all parties hereto.

(c) The contractor will be required to furnish indentification badges for all his employees. These badges will show the employee's photograph, printed name, and signature, and will be of a design approved by the contracting officer.

(d) The contractor, in performing the work required by this contract, shall not discriminate against any worker because of race, creed, color, or national origin.

(e) The contractor agrees that the provisions of paragraph (d) above will also be inserted in all of his subcontracts. For the purpose of this article, a subcontract is defined as any contract entered into by the contractor with any individual, partnership, association, corporation, estate, or trust, or other business enterprise or legal entity, which involves performance, wholly or in part at the site of the work, of some part of the work to be performed under this contract.

1-39. REPORTS TO DEPARTMENT OF LABOR. - The contractor will report monthly, and will cause all subcontractors to report in like manner, within five days after the close of each calendar month, on forms to be furnished by the Department of Labor, the number of persons on their respective payrolls, the aggregate amount of such payrolls, the man hours worked, and the total expenditures for materials. He shall furnish to the Department of Labor the names and addresses of all subcontractors on the work at the earliest date practicable, provided that the foregoing shall be applicable only to work at the site of the construction project. Copies of all data furnished the Department of Labor shall be promptly furnished the contracting officer.

1-40. INVOICES. - The contractor shall furnish the contracting officer with copies of all invoices for the purchase of materials, supplies and plant in connection with the work to be performed under these specifications. The contractor's records shall be subject to inspection by the contracting officer to verify the accuracy and completeness of the information furnished.

1-41. COST DATA. - The Government will keep a record of the costs of the work performed under these specifications and the contractor shall permit the contracting officer to have access to his timekeeping, invoices and plant records for this purpose. The contractor shall also furnish the contracting officer with a statement of the initial cost and date of purchase of all plant used in connection with the work.

1-42. ADJUSTMENT OF CONTRACT PRICE BY REASON OF CHANGE IN FEDERAL, STATE OR LOCAL TAXES. - The contract price will be considered to include all Federal, State and local taxes imposed prior to the date of opening bids and applicable to the undertaking. If any privileges, sales, gross receipts or other tax (exclusive of taxes on net income or undistributed profits), applicable to the undertaking and payable directly by the contractor, is imposed or changed after the date of opening bids by Federal or State enactment, then the contract price will be increased or decreased accordingly and any amount due or chargeable against the contractor as a result thereof will be adjusted on payment vouchers as separate items.

1-43. SUBCONTRACTORS. - Subcontractors and their employees shall be considered to be employees of the contractor as the term "employee" is used in these specifications.

1-44. SITE OF WORK. - The term "Site of the Work", as used in these specifications and in Articles 17 and 19 of the contract, will embrace all areas wherein field operations are conducted by the contractor in connection with this contract, including work areas, shops, yards, camps, etc., irrespective of whether such operating areas lie within the limits of work areas or rights-of-way shown on the drawings.

1-45. ASSIGNMENT OF CLAIMS. - The Act of October 9, 1940 (Public No. 811, 76th Congress) provides that Sections 3477 and 3737, Revised Statutes, shall not apply to any case in which the moneys due or to become due from the Unites States, under a contract providing for payments aggregating $1,000 or more, are assigned to a bank, trust company, or other financing institution, including any Federal lending agency. An assignment may be made under this contract, pursuant to the Act of October 9, 1940, cited above, and subject to the further provision stated below:

(a) Any assignment shall cover all amounts payable under this contract and not already paid and shall not be made to more than one party, except that any such assignment may be made to one party as agent or trustee for two or more parties participating in such financing.

(b) Any claim under this contract which may be assigned may be subject to further assignment to a bank, trust company, or other financing institution, including any Federal lending agency, and to similar further assignment; provided, that any such assignee shall file written notice of the further assignment together with a true copy of the instrument of further assignment with the contractor and also as provided in proviso 4 of section 1 of the Assignment of Claims Act of 1940 (Public No. 811, 76th Congress) in respect of original assignment.

(c) No assignee shall divulge any information concerning the contract, or contained therein, except to those persons necessarily concerned with the transaction.

(d) Payments to an assignee of any claim arising under this contract shall not be subject to reduction or set off for any indebtedness of the assignor to the United States arising independently of this contract.

1-46. ADJUSTMENT OF PRICES FOR LABOR AND MATERIALS.

(a) The following terms used hereafter are defined as follows:

(1) "Basic hourly earnings index" shall be determined by adding monthly average hourly earnings in the "_____" industry as indicated under heading "_____" in the monthly panphlet "Hourly Wages and Labor Employment" issued by the Department of Labor for: the month in which contract time commences, the five (5) months preceding such month, and the six (6) months succeeding such month; and then dividing this total by twelve (12).

(2) "Basic materials index" shall be determined by method in (1) above, using monthly indices for item "_____" in the monthly pamphlet "Wholesale Prices" issued by the Department of Labor.

(3) "Monthly labor adjustment index" shall be determined

from monthly average hourly earnings identified as to source in (1) above as follows: Add the average hourly earnings for the month for which adjustment is being made, the two preceding months and the two succeeding months; and then divide this total by five (5).

(4) "Monthly materials adjustment index" shall be determine by method in (3) above, using monthly indices identified as to source in (2) above.

(5) Above contract indices in (1), (2), (3), and (4) shall be computed to nearest second decimal place, taking the decimal point as located in indices issued by the Department of Labor. When third decimal place computes to 5 or over, the figure in second decimal place shall be raised to next higher figure.

(b) (1) The proportion of the contract price represented by labor, subject to adjustment in price, is accepted as ___ _____ per cent of the contract price.

(2) The proportion of the contract price represented by materials, subject to adjustment in price, is accepted as _____ per cent of the contract price.

(c) (1) The labor cost for entire contract as determined in (b) (1) above shall within thirty (30) days after receipt of notice to proceed, be divided into monthly labor cost quotas, prepared by the contractor and subject to the approval of the contracting officer, for each partial or whole calendar month of the contract time beginning with the notice to proceed.

(2) The materials cost for entire contract as determined in (b) (2) above shall be similarly divided into monthly materials cost quotas within thirty (30) days after receipt of notice to proceed.

(d) Adjustments in payments shall be obtained for each monthly cost quota as follows:- Multiply monthly cost quota by the appropriate monthly adjustment index, divide by corresponding basic index, and subtract monthly cost quota. The result shall be added to or deducted from payments to the contractor.

(e) (1) If the time for performance of this contract is legally extended by the contracting officer, there shall be immediately set up by the contractor, subject to the approval by the contracting officer, new monthly cost quotas as necessary. These new monthly cost quotas may extend back as far as any month for which adjustments in payments have not been completed, but the total of the new quotas shall not exceed the total of the old quotas for which adjustment in payments have not been completed.

(2) If there is an increase or decrease in the work originally contemplated under this contract, there shall be immediately set up by the contractor, subject to the approval of the contracting officer, new monthly costs quotas for months concerned.

(3) If liquidated damages are assessed against the contractor under the contract, such liquidated damages shall not be considered in making adjustments.

(f) The adjustment payment or deduction for any one month shall normally be included with next partial contract payment after receipt of Department of Labor indices for such month.

(g) The acceptance and final payment for work and/or materials under this contract shall be carried out as elsewhere provided in this contract, and amounts retained for the protection of the Government during construction shall be promptly paid upon final acceptance: Provided, however, that an amount, as determined by the contracting officer, for pro-

tection of the Government in adjustments not yet completed, shall be retained; and, provided further, that the release required by _____ _____ will contain provision excepting such adjustment payments as may become due the contractor.

(h) After final payment for basic contractual price as indicated in paragraph (g) above has been made, adjustments becoming due will be delayed until all indices necessary for completion of all adjustments under the contract are available, when one lump payment or deduction shall be made for such adjustments.

(i) In case the final adjustment in the contract price results in a net deduction from the contract price, the contrator and his sureties shall be liable for the amount thereof until it is refunded to the Government.

(j) When payment obligations under the contract exceed the contract price as a result of increases in labor and/or materials costs to the extent that available appropriations are exhausted, the Government reserves the right, without further liability to suspend further work under the contract for the account of the Government or to terminate the contract on payment of contractual obligations incurred up to the point of termination.

1-47. FINAL EXAMINATION AND ACCEPTANCE. - When all work called for under this contract has been completed, the contracting officer will make a thorough examination of the same, and, if it is found to comply fully with the requirements of the contract, it will be accepted and final payment will be made in accordance with the provisions of Article 16d of the contract.

1-48. APPROVAL. - This contract shall be subject to the written approval of the proper authorities to be designated later and will not be binding until so approved.

SECTION II - DIVERSION AND CARE OF THE RIVER

2-01. WORK TO BE DONE.

(a) The work included under this section covers all required work in connection with the handling of water during the entire construction period of the dam and appurtenant works. The principal items of work which are included are as follows:

(1) Diversion of the river during the construction period, including excavation and maintenance of diversion channels, and filling and removing the Massena Power Canal diversion weir.

(2) Construction, maintenance, and removal of cofferdams and other protective structures, including diversion gates and operation of such gates as specified in paragraph 2-14.

(3) Unwatering and maintaining working areas free from water.

(b) Unless otherwise specified or authorized, all work on construction which forms a part of the permanent structure shall be done in areas free from water. The contractor shall construct and maintain all necessary cofferdams and diversion structures, and shall furnish and operate all necessary pumps and other facilities for unwatering and maintaining the various areas of the work free from water as required by the contracting officer. The contractor shall, on completion of the work, remove all cofferdams, equipment, and temporary construction as hereinafter specified, objectionable debris shall be disposed of, and the work area shall be left in a neat and sightly condition to the satisfaction of the contracting officer.

2-02. GENERAL.

(a) Scope of Work. - The contractor shall be responsible for the furnishing of all materials except as specified herein (see also paragraph 1-10), equipment, and labor for properly constructing, handling, placing, operating, maintaining, and removing of all items included in the work; and for the adequacy and safety of such items except as specified herein. The price bid for each item of work shall include all the above enumerated factors except as specifically stated in these specifications.

(b) Materials furnished by the Government.- Cofferdam materials and equipment to be furnished by the Government are timbers for timber cribs, and the necessary drift pins, bolts, washers, and tie rods; cement and concrete aggregates; concrete reinforcement; diversion gates, tracks, dogging equipment, and accessories for diversion gates; and the spillway gantry crane No. 1 for operating diversion gates. Borrow areas will be designated on the drawings from which the contractor may obtain earth fill, (see paragraphs 1-16 and 3-02(b)).

2-03. RESPONSIBILITY FOR COFFERDAMS.

(a) The Government will be responsible for the design and adequacy of the cofferdams and diversion structures of the scheme specified herein and shown on the drawings, except for failure or damage resulting from negligence on the part of the contractor, but not as hereinafter

specified (see paragraph 2-04), for alternate cofferdams and/or diversion sturctures proposed by the contractor. In the event of failure or overtopping of the cofferdams or diversion structures, the contractor shall repair any damage, including cleanup of debris, to any part of the temporary facilities or permanent construction; and he shall be paid for such work in accordance with articles 3 and 4 of the contract and the time of completion shall be extended by an amount equal to the time lost as determined by the contracting officer. In addition to the payment specified for the work done, he shall be paid a lump sum of $15,000 as compensation for extra expenses for each such failure or overtopping; provided, that no additional such payment shall be made in the event of a subsequent failure or overtopping prior to resumption of work after a failure or overtopping. No payment will be made for damage to the contractor's equipment or materials.

(b) In the event that it appears probable that the cofferdam may fail or be overtopped, the contractor may be required to flood the cofferdam. In such event he shall be paid for cleanup, repairs, and $15,000 for extra expense, and the time of completion shall be extended, all as herein provided for failure or overtopping.

(c) The contractor shall repair, in a satisfactory manner, any damage to the permanent structure caused by scour of ice or water; and he shall be paid for such work in accordance with articles 3 and 4 of the contract.

(d) Any part of the temporary or permanent structures which may fail or be damaged due to negligence on the part of the contractor and any damage resulting therefrom shall be repaired or replaced by the contractor at his expense.

2-04. ALTERNATE COFFERDAM AND/OR DIVERSION PLANS.

(a) Bidders may submit plans for cofferdams and/or diversion other than those specified but such alternate cofferdams must have stability, height, watertightness, and working space within the cofferdams at least equal to the specified plans; and the diversion plans must be adequate to allow complete regulation of the river as required to prevent interference with other functions.

(b) The contractor shall sssume full responsibility for the design, safety, and adequacy of such alternates, except for overtopping where the cofferdams are constructed to the heights required in the specified plan, and no payment will be made for repairs or cleanup resulting from failure of such alternate cofferdams nor will an extension of time be allowed for time lost. The Government will, however, assume responsibility for overtopping provided the cofferdams are built to the height required for the specified cofferdams and further provided that any earth or rock structure is built to an elevation not less than 4 feet above the elevation specified for a corresponding crib structure. In the event of overtopping where cofferdams are built to the specified elevations, payment will be made and extension of time granted as provided in paragraph 2-03 of these specifications.

2-05. RIVER REGULATION.

(a) General. - Throughout the construction period it will be necessary to regulate the diversion and construction in such manner as to maintain satisfactory navigation conditions and also to maintain satisfactory water levels at the intake of the Massena Power Canal. The contractor shall regulate his construction program in accordance with the regulation as described and specified herein; and he shall not receive payment or extension of time for time lost due to such regulation.

(b) Lock 21. - The minimum water surface elevation at Lock 21 required to maintain 14-foot navigation through the lock is elevation 199. The maximum water level allowable under present conditions is elevation 205; but the Government will raise the lock and dikes to elevation 210. A curve of stage-discharge relation at Lock 21 is shown on sheet 5 of the plans.

(c) Navigation in the vicinity of Lock 21 during first and second stages. - Inasmuch as any lowering of the water surface at Lock 21, below the normal elevation corresponding to a given discharge, will increase the velocity of the flow upstream, thus interfering with navigation, it will be necessary to maintain water surface elevations at Lock 21 at or above the normal during the navigation season, except as modified by the contracting officer.

(d) Navigation during third stage (closure of dam). - Navigation in the 14- foot Cornwall Canal will continue until the pool is to be raised. At this time the pool will be raised rapidly from elevation 209 to elevation 225, or higher, at which latter elevation 14-foot navigation can use the completed Long Sault Canal. During this transition period 14-foot navigation would be suspended. The rate at which the pool can be raised and therefore the time navigation is suspended will be limited by the following two controlling factors other than the work included in this contract:

(1) The permissible reduction in river flow to provide water to fill the pool and

(2) The time required to make closures in the existing 14-foot canal system.

As neither of these factors should require a transition period of more than a week, the contractor shall so arrange his operations that the time during which navigation is suspended shall not be increased beyond the above period.

(e) Massena Intake. - A curve showing the relation between the water surface elevation above the Massena Power Canal Diversion Weir and the discharge of the river is shown on sheet 5 of the plans. It will be necessary to maintain the water surface elevations at the Weir at elevations corresponding to present conditions until such time as construction of the proposed intake structure permits higher stages.

2-06. CONSTRUCTION PROGRAM AND DIVERSION PLAN.

(a) A construction program and diversion plan, which provides for the particular requirements for the care of the river during construction has been prepared as described herein. Construction of the dam shall be accomplished in two sections, as shown on sheets 10 to 14 of the plans; and shall comprise three construction stages

to be completed in the following order: (1) The south section of the dam and diversion cuts 'C', 'F', and 'G', (2) The north section of the dam and (3) closure of diversion openings. Diversion during each of these construction stages and the order of work is as follows:

(b) First Stage. - During the first stage the main flow of the river will be continued in the existing Long Sault Island Main Channel and the flow of the Long Sault Island South Channel is to be diverted through cut 'C'. Prior to construction of cofferdam 'A', the Massena Power Canal Diversion Weir shall be closed and raised sufficiently to permit placing cofferdam 'A' as a rock and earth fill, and cut 'C' shall be excavated. Upon completion of cofferdam 'A' the Massena Weir shall be restored to approximately its original condition. Construction of the south section of the dam with the exception of the 40-foot diversion openings to be left at elevations 160, 163, and 165 in spillway bays B1 to B13 inclusive as shown on sheet No. 18 of the plans, shall be completed to a point which will enable operation of the gantry crane No. 1. Prior to removal of the first stage cofferdams, diversion gates shall be placed in each of the 13 diversion openings as shown on Sheet No. 28, bulkheads upstream and downstream and downstream of B14 shall be constructed, cut 'G' shall be completed with the exception of a plug at the end of cofferdam 'A' and cut 'F' shall be completed with the exception of a plug at the upstream end.

(c) Transition from First Stage to Second Stage. - On the completion of the first stage construction the diversion gates shall be closed and cofferdams 'A' and 'B' removed. A plug shall be placed across cut 'C', as shown on sheet 12 of the plans and the plug of cut 'F' removed. The Massena Power Canal Diversion Weir shall then be removed and cofferdam 'E' constructed, followed immediately by construction of cofferdam 'DD'. During the construction of cofferdam 'E', and subsequently during second stage diversion, the diversion gates shall be operated, as directed by the contracting officer, to maintain required water surface elevations at Lock 21 and at the Massena Power Canal Intake.

(d) Second Stage. - During the second stage the flow of the river will be diverted through cut 'F' and the Long Sault Island South Channel and through the 13 diversion openings left in the first stage construction. Construction of the north section of the dam shall be completed with the exception of a 40-foot diversion opening at elevation 190, in each of five spillway bays, B16 to B20 inclusive, and such work as can be carried on during the third stage. These openings shall be fitted with diversion gates similar to those in the first stage construction as shown on sheet No. 28. Remove cofferdams 'E', 'DU', and 'DD' described in paragraph 2-09(d).

(e) Third Stage Closure. - The closure plan shown on the drawings and described in detail in these specifications is the plan recommended by the Government. The diversion gates for use in this plan will be assembled by attaching the upper section of a permanent spillway gate to a full height spillway gate as shown on sheet No. 28. These diversion gates shall close off successive groups of diversion openings permitting placing of concrete while the river flow is diverted through the remaining diversion openings. Successive step by step moves are shown in the Closure Operation Schedule on sheet 28. It should be noted that moves 1 to 8 inclusive are made with the pool held to elevation 209.0 or below. Moves 9, 10, and 11 are made with the pool at elevation 226 to permit 14-foot navigation through Long Sault Canal.

For a normal year all the diversion gates may be closed for move 12. For abnormal years it may be necessary to leave some openings in addition to the completed spillway bays to maintain the water surface

above the dam to an elevation below the top of the diversion gates. During this move the concrete can be brought up by successive five-foot lifts to full crest elevation.

The closure plan has been developed anticipating a normal flow in the river at time of closure, and minimum total river flow of about 228,000 c. f. s. can therefore be handled with the openings provided. If higher river discharges are anticipated it will be necessary to provide additional diversion openings in the second step construction. In addition to the 18 diversion openings provided, sufficient gates will be made available for a maximum of six openings to be left at elevation 190 in the second stage construction if it is anticipated they will be required. Each of these openings at elevation 190 would pass approximately 5,000 c.f.s. as a minimum. While the contracting officer anticipates that at the control dam at Iroquois Point will be completed and in operation before the closure of the Long Sault Dam and can be used to control the river flow, it must be understood that many factors will dictate the method of operation of the Iroquois Dam. Discharges no higher than exist in nature will be passed down the river during the closure period. Probably the river flow can be reduced, but accurate prediction of the amount by which the flow can be reduced is impossible due to the uncertainty of the level of Lake Ontario and lower river conditions.

2-07. ALTERNATE CLOSURE PLAN. - The contractor may submit his own scheme for closure which, subject to the approval of the contracting officer, he may adopt. In any scheme of closure which the contractor may select, the permanent facilities such as gantry crane No. 1 and the spillway gates will be made available for his use. However, the contractor will be required to recondition all permanent facilities used for diversion purposes as specified in paragraph 2-14 of these specifications. Certain design requirements peculiar to the closure scheme selected may necessitate strengthening or modification of the concrete structures. If the selected and approved closure scheme necessitates additional material and labor not required in the Government plan, or results in an increased cost for modifications or strengthening of the spillway gates, gantries, or other facilities furnished by the Government, the contractor will be required to furnish at his own cost the additional material and labor, or in the case of materials and facilities furnished by the Government, he will be required to reimburse the Government the amount of such increased cost including engineering and overhead. The intent of these specifications is to give the contractor latitude in selecting a closure scheme best suited to his particular construction methods and still furnish without additional cost to the Government a satisfactory completed structure. Regardless of the plan selected, the contractor shall be required to notify the contracting officer within 30 days after receipt of notice to proceed what plan he proposes to use in order that materials furnished by the Government may be available when required (see paragraph 1-10).

2-08. DIVERSION EXCAVATION PROGRAM.

(a) Program. - Excavation of cut 'C' shall be completed prior to closure of cofferdam 'A'. Excavation of cut 'G' with the exception of a plug at the end of cofferdam 'A' shall be completed after the area within cofferdams 'A' and 'B' has been unwatered and prior to removal of cofferdams 'A' and 'B'. The plug in cut 'G' at the end of cofferdam 'A' shall be excavated at the time of the removal of cofferdam 'A'.

Excavation of cut 'F' shall be carried on at a rate to insure completion by the time the first stage construction is completed. A plug shall be left in the upstream end of cut 'F' which shall be removed prior to closure of cofferdam 'D' after removal of cofferdam 'A' and 'B'. The plug in cut 'C' shall be in place and the upstream portion of cofferdam 'DU' shall be built to elevation 205 before the plug in cut 'F' is removed.

(b) Diversion Cuts 'C', 'F', and 'G'. - Diversion cuts 'C', 'F', and 'G' shall be excavated to the lines and grades shown on the plans. The results of explorations to determine the character of the materials to be found are shown on sheets 6 to 9 of the drawings, but the Government will in no way be responsible for the deviation of the material from the characteristics shown and the contractor shall be responsible for investigating the conditions for the purpose of making his bid (see paragraph 1-18). Excavation for diversion cuts shall be defined as follows:

Excavation; Diversion Cuts, Rock - All bedrock required to be excavated which, in the opinion of the contracting officer, cannot be removed without continuous and systematic blasting, and all boulders and loose rock two cubic yards in volume or greater will be classed as rock excavation.

Excavation; Diversion Cuts, Earth. - All other material will be classified as common excavation, including boulders and loose rock less than two cubic yards in volume. (see paragraph 2-15(j))

2-09. COFFERDAM PROGRAM.

(a) The proposed cofferdam layout and construction details are shown on sheets 10 to 18 of the plans. In general, cofferdam cribs in locations exposed to high velocities of flow shall be founded on rock and protected by steel sheet piling; while cribs not so exposed shall be founded on the river overburden and protected by impervious earth blankets having a toe trench extending to rock or impervious materials and backfilled with impervious earth. Cofferdam 'E', which is exposed to high velocities of flow only during placement and closure, is founded on rock and the whole protected by an earth blanket. Earth and rock embankments and shore fills are founded on river overburden and provided with toe trenches as above described for blanket fills.

(b) First Stage Cofferdams. - Cofferdams 'A' and 'B' shall be constructed as shown on sheet 11 of the plans to inclose the south section of the dam to and including pier 14. Cofferdam 'A' shall be an earth fill structure built to elevation 192 and cofferdam 'B' shall be a crib structure built to elevation 188. That portion of cofferdam 'B' which is located upstream from the dam axis, and which is common to the second stage cofferdams, shall be built to a minimum elevation of 188 for the first stage and shall be raised to elevation 205 for the second stage.

(c) In order to reduce the flow in the Long Sault Island South Channel sufficiently to permit construction of an earth and rock cofferdam, the contractor shall close off and build up the existing diversion weir of the Massena Power Canal to elevation 205 as shown on sheet 16 of the drawings. Immediately after completion of cofferdam 'A', and in any event prior to the beginning of the ice season, the contractor shall restore the diversion weir to approximately its present condition.

(d) Second Stage Cofferdams 'E', 'DU', and 'DD'. - Cofferdams 'E', 'DU', and 'DD' shall be constructed to inclose the north section of the dam. Cofferdam 'E' shall be built to elevation 210, cofferdam 'DU' upstream shall be built to elevation 205, and cofferdam 'DD' and 'DU' downstream shall be built to elevation 188. That portion of cofferdam 'B' comprising cribs 23 to 27 inclusive shall be left in place to form part of cofferdam 'DU'. The construction of cofferdam 'E' may, with prior approval of the contracting officer, be initiated prior to completion of cut 'F' but until cut 'F' has been completed such construction shall not proceed beyond the point where, in the opinion of the contracting officer, interference with navigation facilities might result.

(e) Bulkhead Sections.-The cribs or sections of cofferdam 'DU', upstream and downstream, adjacent to and abutting on the completed spillway section and which may be built within the unwatered first step cofferdams, shall be constructed to fit the concrete section and shall be made water-tight by sheathing the outside and sealing the contracting edges as shown on the plans.

(f) Plug Across Cut 'C'. - After the removal of cofferdams 'A' and 'B' and prior to the commencement of cofferdam 'E', the contractor shall construct and maintain a plug or embankment across cut 'C' to the grade and section as shown on sheet 12 of the plans. The contractor may, with prior approval of the contracting officer, construct this plug of any material and by any means deemed suitable. The contractor will not be required to remove this plug after completion of the work.

(g) Barnhart Island North Channel. - The Barnhart Island North Channel will be closed as part of another contract and the contractor shall not be required to undertake any work in closing this channel or to assume any responsibility for failure or overtopping of any cofferdam placed across this channel.

2-10. COFFERDAM CONSTRUCTION.

(a) Cofferdam Foundation Excavation. - In locations where the plans show cofferdam cribs founded on rock the contractor shall excavate all overburden and remove all rock irregularities or pinnacles which will interfere with the proper placing and maintaining of the cofferdams. The area so excavated shall have a bottom width extending to a distance of 10 feet outside the limits of the cribs to be founded on rock and shall have slopes of 1 on 1.5; except that foundation excavation for cofferdam 'E' shall extend for a distance of 20 feet upstream from the upstream edge of the cribs, 10 feet downstream from the downstream edge of the cribs, and shall be continuous throughout the length of that portion of the structure founded on rock, including stop log openings, for a distance of 10 feet beyond the outside limits of the outside cribs to be founded on rock. Toe trenches for earth and rock embankments and blanket fills shall have a bottom width of 10 feet and side slopes of 1 on 1.

(b) Timber Cribs (in Place). - Cofferdam cribs shall be constructed and placed as shown on sheets 10 to 14 of the plans. The base of each crib shall be shaped or tailored, in vertical steps equal in height to one horizontal course of timber, to fit the crib foundation as determined by soundings to be taken prior to construction of the cribs and subsequent to any required excavation. Timbers shall be fastened by means of drift pins or bolts as shown on the plans. Joints in horizontal courses shall be staggered so that two consecutive joints in a vertical plane shall not occur within the limits of one crib pocket and shall be

so placed that a joint does not occur immediately under a cross timber. Butt joints shall be fastened by means of splice blocks. Holes for drift pins shall be bored with a bit 1/16-inch in diameter less than the thickness of the pin, holes for bolts shall be bored with a bit equal in diameter to that of the bolt, and holes for tie rods shall be bored with a bit 1/16-inch in diameter larger than the rods. Standard washers shall be used under all bolt heads and nuts which would otherwise come into contact with the wood. Drift pins shall be square in section, square ended, and without taper.

(c) Timber lengths will be such that not more than one butt joint will occur in any one horizontal member for cribs exceeding 30 feet in width. For cribs up to and including 30 feet in width timbers will be furnished in lengths equal to the width of the crib. Timbers for weight pocket flooring will be furnished in standard lengths closest to the length required.

(d) Crib Sheathing (Bulkhead). - The outside face of bulkhead cribs shall be protected by a water-tight sheathing as shown on sheet 14 of the plans.

(e) Steel Sheet Piling. - Steel sheet piling shall have a minimum web thickness of 3/8-inch and shall weigh not less than 31 pounds per square foot of wall. Piling shall be driven to form a tight seal at the foundation and shall be interlocked throughout their length so as to form a continuous wall. Proper precautions shall be taken to prevent interlock rupture or other injury to the piles, and any piles improperly driven or injured in any manner shall be removed and replaced at the contractor's expense. Where piling is driven as a double row or a series of connected cells, the space between the rows shall be backfilled with an impervious material so as to effectively seal the foundation against seepage under the cribs. The space above the seal shall be left open in order that the piling may be sealed at the interlock by water pressure.

(f) After removal from a cofferdam, steel sheet piling shall remain the property of the contractor, and, if in a satisfactory condition, may be re-used by him in another part of the cofferdams.

(g) Crib Fill. - Crib fill shall be quarry run rock. Fill shall be placed in the weight pockets at the time of placing the cribs to trim and sink the cribs. After the cribs are in place on the crib foundation all pockets shall be completely filled.

(h) Earth Fill, Cofferdam. - Earth fill in cofferdam embankments or blanket fills shall be impervious earth material placed by dumping or by other suitable method. The material shall be well-graded clayey or silty sand and gravel, and of the material passing the ¾-inch screen, at least 25 percent by dry weight shall pass the 200 mesh screen. Material meeting these specifications is available from the required excavation or borrow areas indicated.

(i) Rock Fill, Cofferdam. - The function of the rock fill in cofferdam embankments is to form an initial fill to the surface of the water so that the flow will be sufficiently stopped to permit placing earth fill. The material may be quarry run rock and it shall be placed to the slopes as shown in the plans and to the height of the surface of the water at the time of placing.

(j) Riprap - Cofferdam. - Riprap shall consist of stones weighing, in general, 250 pounds or more, and not less than 15 pounds; placed to a thickness of 3 feet in a direction normal to the slope of the embankment. No hand placing or sorting shall be required but the finished surface shall conform to the slope lines as shown in the plans. Any rock used to fill

depressions or irregularities in the embankment shall be placed at the contractor's expense.

(k) Derrick Stone. - Derrick stone shall consist of stone weighing not less than 1,000 pounds and having a least dimension not less than one-half the greatest dimension. It is not anticipated that derrick stone will be required, but the contracting officer may require that derrick stone be placed where excessive scour or high velocities of flow make such portection necessary or desirable.

(l) Stop Logs, Concrete. - Concrete stop logs, as shown on sheet 14 of the plans, shall be provided for closing cofferdam 'E'. Concrete shall be class A conforming to the requirements of Section V. The contractor may provide holding rings or devices other than as shown on the plans in order to permit the use of lifting devices proposed by him; but such holding rings must be placed so that the stop logs shall fit tightly together in the stop log grooves, and so that the strength of the stop logs are not less than in the plan shown. Stop logs shall be so placed that the surfaces of adjacent logs are in intimate contact throughout their length. The contractor shall be responsible for handling and placing stop logs and any logs broken or damaged shall be replaced by him at his expense.

2-11. MASSENA WEIR.

(a) General. - The plans and sections of the existing weir as shown on sheet 16 of the drawings are approximate only, and the weir is, at the time of writing these specifications, undergoing repairs and alterations. The material comprising the weir is a heterogeneous mixture primarily of concrete and rock. The contractor shall be responsible for determining the conditions existing at the weir for the purpose of his bid and the Government will in no way accept responsibility for the accuracy of the data shown.

(b) Fill, Massena Weir. - Prior to constructing cofferdam 'A', the contractor shall fill the Massena Weir to elevation 205 and to the sections as shown on the plans. The fill need not be water tight but shall be constructed so as to permit placing of cofferdam 'A'. Immediately after the construction of cofferdam 'A', and in no event later than the beginning of the ice season, the contractor shall return the weir to approximately its present condition.

(c) Removal of Massena Weir. - The contractor shall, after removing cofferdams 'A' and 'B' and prior to closure of cofferdam 'E', remove the diversion weir of the Massena Power Canal to the limits as shown on sheet 16 of the drawings. The contractor will not be required to remove the material completely from the channel but all such material shall be disposed of in such manner that the flow of the channel is not unduly obstructed or restricted. Such material as may be satisfactory may be used in other structures where such material is required.

2-12. UNWATERING COFFERDAMS. - After completion of the cofferdams as shown for each construction stage the contractor shall unwater the cofferdammed area and shall maintain each part of the work free from water as required for the prosecution of the work. The amount of water removed will be measured from the hours pumped, head, and test rating of the pumps used; or by weirs or other suitable method. The contractor shall furnish, install, maintain, and operate equipment for measuring the water removed.

2-13. REMOVAL OF COFFERDAMS.

(a) After the completion of the work inclosed by the various cofferdams, the cofferdams shall be removed as specified below to the satisfaction of the contracting officer.

(1) Cofferdam 'A': Prior to the closure of cofferdam 'E', cofferdam 'A' shall be completely removed to or below elevation 167. The contractor shall remove from the channel all fill or debris which may impede the flow through the channel.

(2) Cofferdam 'B': Cofferdam 'B', from the U. S. shore to and including crib 14, shall be removed prior to closure of cofferdam 'E' to elevation 155 or to the river bottom, whichever shall be highest.

(3) Cofferdam 'DU': Cofferdam 'DU' shall be removed to elevation 175 for a distance of not less than 100 feet or as otherwise required for diversion through openings in the second stage construction. In the event that the final, or closure, stage of construction does not require diversion through spillway openings in the second stage construction, cofferdam 'DU' need not be removed.

(4) Cofferdam 'DD': Cofferdam 'DD' and bulkhead downstream of B14 shall be completely removed to elevation 155(river bottom).

(5) Cofferdam 'E': Cofferdam 'E' shall be completely removed to elevation 180.

(b) All materials in the cofferdams, including materials furnished by the Government for use in the cofferdams, shall become the property of the contractor and shall be disposed of by him. Earth and rock removed from the cofferdams, except cofferdam 'A', may be wasted in the river downstream from the cofferdams from which they are removed or in the areas designated on the plans for waste. Material wasted in the river shall be distributed in such manner that it shall not accumulate in piles or mounds nor to an elevation higher than the grade specified for removal of the cofferdams. Materials from cofferdam 'A' shall be completely removed from the river or wasted downstream from the dam. All timbers or other floating material shall be removed from the river.

2-14. DIVERSION REGULATION AND GATES.

(a) Regulation. - Regulation of diversion during the second and the closure stages will be accomplished by operation of diversion gates. Inasmuch as the United States is responsible for any damage resulting from improper regulation of the waters surface elevations at upstream points, the diversion gates shall be operated only as directed by the contracting officer and the contractor shall not at any time operate these gates except by written authority of the contracting officer.

(b) Diversion Gates.

(1) As noted in paragraph 2-06(e), each diversion gate is to be made up of one top section of a spillway gate resting on the coupled to a single-section spillway gate. A temporary steel seal structure will be furnished on the skin plate side of each gate section and a rubber seal and air hose with fittings provided. The contractor shall make the permanent splices in the gates as required in paragraph 7.02(e)

and shall also make watertight splices in the steel seal structures. The horizontal seals shall be attached to each top section, the completed sections coupled together, and watertight splices made in the seal structure at the joints. The air hose shall then be inserted at the back of the seal retaining slot andthe rubber seal placed at the front and the joints in the seal cemented. The completed gates, with wedge-operating motors and limit switches removed, shall then be transported to the proper openings and placed in the slots by gantry crane No. 1.

(2) When the gates are no longer needed for river diversion, the contractor shall remove the temporary seal structure by a method which will not injure the gates, recondition the gate sections and equipment to first-class condition, attach the permanent seals, wedge operating motors and limit switches, and shall then place the gates in the proper spillway slots as required by Section VII. Reconditioning of the gates shall include thorough inspection and reconditioning of all working parts, particularly the wheel assemblies, greasing systems and the lifting and coupling mechanisms. Any parts injured due to their temporary use for river diversion shall be replaced by the contractor at his expense. The contractor shall also fill from elevation 215 to the top of the piers the niches left in the pier noses with Class B concrete, properly anchored and reinforced as indicated on the drawings. The finished surfaces shall conform to the curve of the pier faces.

(3) Tracks. - The gate tracks will be 175 lb. crane rails clamped to wide-flange bearing beams. The contractor shall place all anchor bolts in the pier concrete and shall attach the gate tracks and grout them in place after he has carefully adjusted them to line. After the diversion gates are removed, the contractor shall have the option of removing all of the track rails for use later in the permanent gate slots, or he shall furnish at his expense similar track of equal quality and proper length for installation in the permanent gate slots. The contractor shall inform the contracting officer in writing of his choice before completion of work in the first stage cofferdam. In the event the contractor decides to purchase new rails instead of salvaging from under water the rails used in the diversion openings, the Government will furnish him the specifications for the rails to be bought.

(4) Dogs and operating devices will be furnished for installation in the pier noses at the locations shown on the drawings. The contractor shall install the dogs, supporting steel, operating rods and fastenings. After the diversion gates are removed the contractor shall remove the dogs, pins, operating rods and fittings for installation in the permanent gate slots as required in Section VII.

(c) Gantry Crane No. 1. - The spillway gantry crane No. 1 will be used for operating the diversion gates and for any material handling or other service for which it is suited. The contractor shall furnish electric power and competent operators, and shall recondition the crane as provided in paragraph 7-10.

2-15. MEASUREMENT AND PAYMENT.

(a) Excavation; Crib Footing. - A survey of the river bed will be made prior to commencement of work, and measurement for excavation will be made between the ground surface and the slope and grade lines specified, see paragraph 2-10(a), or shown on the drawings, and to the rock surfaces upon which the cofferdam cribs are founded. Payment for such excavation for cofferdam cribs including toe trench excavation for earth and rock embankments for cofferdams will be made at the contract unit price per cubic yard for "Excavation; Crib Footing." Excess material excavated outside the limits specified shall not be included for payment.

(b) Timber Cribs. - Payment for timber cribs, see paragraph 2-10(b), shall include all the work of unloading, transporting, storing, constructing, and placing as specified and shown on the drawings, and shall include placing drift pins, bolts, washers, tie rods, and other items necessary. Payment will be made at the contract unit price per thousand board feet for "Timber Cribs" after a crib has been set and stabilized with fill. The number of board feet shall include all the crib timber in place except the sheathing lumber. Dimensions of timber serving as a basis for computation of quantities of board feet will be in accordance with standard grading rules of the applicable lumber organization.

(c) Crib Sheathing (Bulkhead). - Payment for furnishing and placing cribsheathing will be made at the contract unit price per square foot for "Crib Sheathing (Bulkhead)" as indicated in the Schedule of Bid Items.

(d) Steel Sheet Piling. - Payment for furnishing and placing steel sheet piling will be made at the contract unit price per square foot for "Steel Sheet Piling", for the number of square feet of wall below the specified grade line. This payment shall include all items of work in connection therewith including the seal backfill as specified.

(e) Crib Fill. - Crib fill, paragraph 2-10(g), shall be measured in place to the inside dimensions of each crib pocket. Payment will be made at the contract unit price per cubic yard for "Crib Fill", and shall include all costs of furnishing and placing the quarry run rock for crib fill.

(f) Earth Fill, Rock Fill, and Riprap. - These items, paragraphs 2-10(h), (i), and (j), shall be measured in place to the slope lines and grades as specified or shown on the drawings. Payment will be made at the contract unit prices per cubic yard for "Earth Fill; Cofferdams", "Rock Fill; Cofferdams", or "Rip rap; Cofferdams" respectively, and shall include all costs of furnishing and placing the earth fill, rock fill, and riprap in the cofferdam embankments.

(g) Derrick Stone. - This item, paragraph 2-10(k), shall be measured by the ton, and the contractor shall furnish scales and a suitable shelter for weighing the material at the site of the work. Payment will ge made at the contract unit price per ton for "Derrick Stone; Cofferdams", and shall include all cost of furnishing and placing the derrick stone as specified.

(h) Cofferdam Removal. - Cofferdam removal shall be measured on the basis of material actually in place above the grade specified for removal, see paragraph 2-13, and no classification of material will be made. Payment will be made at the contract unit price per cubic yard for "Cofferdam Removal", and shall include the cost of all work as specified including disposal and cleaning up.

(i) Unwatering Cofferdams. - Payment for unwatering cofferdams will be made at the contract unit price per acre foot for "Unwatering Cofferdams", measured as specified (see paragraph 2-12).

(j) Excavation; Diversion Cuts, Earth and Rock. - A survey of the ground surface will be made prior to commencement of work, and measurement for excavation will be made between the ground surface and the slope and grade lines as specified, see paragraph 2-08, or shown on the drawings.

(1) Payment for excavation of the several diversion cuts will be made at the contract unit price per cubic yard for "Excavation; Diversion Cuts, Earth", and "Excavation; Diversion Cuts, Rock" respectively.

(2) Payment for common excavation which, in the opinion of the contracting officer, cannot be removed by a 2½ cu. Yd. power shovel without continuous and systematic blasting will be made at twice the contract unit price per cubic yard for "Excavation; Diversion Cuts, Earth".

(k) Massena Weir. -

(1) Fill. - Payment for filling the Massena Weir, paragraph 2-11, will be made at the contract unit price per cubic yard for "Fill; Massena Weir, Rock", measured to the grade and slopes indicated on the drawings.

(2) Excavation. - Measurement of quantities removed will be based on surveys made before and after removal. Material removed in returning the weir to its original condition after the construction of cofferdam 'A' shall be included in the quantities for the excavation of Massena weir. Payment will be made at the contract unit price per cubic yard for "Excavation; Massena Weir".

(l) Stop Logs. - Payment for stop logs will be based on the cubic yard volume of all the stop logs placed, and shall include the cost of all work in connection therewith including furnishing all items except cement, aggregates, and reinforcement which are furnished by the Government. Payment will be made at the contract unit price per cubic yard for "Stop Logs; Concrete".

(m) Diversion Gates. - The contractor shall perform all work necessary for erecting, operating, and maintaining the river diversion gates, tracks, dogs, and appurtenances; for dismantling the diversion gates and reconditioning the component gate sections for permanent use on the spillway; for returning to the Government undamaged the diversion gate dog castings, pins, track rails and accessories, and the diversion gate sealing equipment; and for placing reinforcing steel in the niches left in the pier noses and filling the niches with concrete to conform to the curve of the pier faces, all as specified in paragraph 2-14. The Government will furnish the materials and items specified in paragraph 2-02(b), but replacement parts for repairs during diversion gate operation

and for reconditioning shall be furnished by the contractor. Payment for erection, operation, maintenance, removal, and reconditioning of the diversion gates including all the items referred to above or herein will be made at the contract lump sum price for "Diversion Gates; Operation and Maintenance".

SECTION III

DAM AND DIKE EXCAVATION, FOUNDATION PREPARATION, AND GROUTING

3-01. CLEARING AND GRUBBING.

(a) Clearing. - The entire work areas as shown on the contract drawing, sheet No. 2, shall be cleared as specified below.

(1) Foundation and Borrow Areas. - The foundation areas for the structures and embankments and the borrow areas shall be cleared of all trees, stumps, brush, fences, buildings, and any other objectionable material or structures.

(2) Spoil Areas. - In areas to be covered by spoil, trees shall be cut off at elevations not higher than 4 feet below the top of the spoil dump.

(3) Reservoir Areas. - Areas upstream from the dam within the limits indicated on the drawing and below elevation 250 shall be cleared of trees, brush, fences, buildings, and any other objectionable materials or structures. All trees shall be cut off 2 feet above the ground surface except that no stumps shall remain above elevation 230. Where trees stand on ground between elevation 230 and 250 they shall be cut off flush with the ground.

(4) Other Areas. - The work area for access railroad and highway shall be cleared and grubbed as specified in paragraph 13-03. Other areas not included in the above within the work areas shown shall be cleared only to the extent necessary for the contractor's camp, storage areas, shops, plant, and the conduct of the work.

(b) Grubbing. - Foundation areas for the embankments shall be grubbed of all stumps, perishable material, and roots greater than 1½ inches in diameter to a minimum depth of four feet below the original ground surface.

(c) Disposal. - All trees, stumps, roots, brush, falling timber, buildings, and other debris cleared within the areas indicated above shall be burned, buried in spoil areas, or otherwise completely removed from the site to the satisfaction of the contracting officer. Disposal in the river of trees, stumps, roots, and other harmful material will not be permitted, and no material shall be piled in the stream bed, or on the river terrace, where it may be washed away by high water. The contractor shall be responsible for any damage done by fire, and shall at no time leave a fire unattended until it has been fully extinguished.

(d) Measurement and Payment. - No separate payment will be made for clearing and grubbing but the costs for such work shall be included in the contract priced for other items of work.

3-02. EXCAVATION REQUIREMENTS.

(a) Excavation and stripping shall be carried to the lines and grades shown on the drawings or as directed by the contracting officer. Excavation and foundation preparation for the various sections of the dam and dike shall be performed in accordance with paragraph 3-06, 3-08, 3-09, and 3-10 of these specifications, or as otherwise directed by the contracting officer.

(b) Borrow Pits. - The designated borrow areas to obtain embankment materials are indicated on the drawings (see paragraph 1-16).

It is estimated that in the designated borrow areas and in the required excavation there is sufficient quantity of suitable material for the compacted fill sections of the embankments, but if, in the opinion of the contracting officer, additional borrow pits are required, they will be furnished without cost to the contractor. If the contractor desires to use the borrow area designated on the drawings on the New York mainland for other purposes, the contracting officer will select another area in the vicinity, containing suitable material. If the borrow area is changed at the request of the contractor, the unit bid price shall not be increased.

3-03. CHARACTER OF MATERIALS TO BE EXCAVATED. - The location and logs of borings, test trenches, and test pits referred to in paragraph 1-18 (a) made by the United States to determine the character of materials to be encountered and removed or to be used in the permanent structures are shown on the drawings or are available for inspection at the U. S. Engineer Office, Massena, New York. The United States does not guarantee that other materials will not be encountered nor that the proportions of the several materials will not vary from those indicated by the explorations. (see paragraph 1-18 (a)).

3-04. EXCAVATION IN BORROW PITS AND STOCK PILES.

(a) Borrow Pits. - The contracting officer will specify the location at which borrow excavation will be made within the borrow areas. The specified areas shall be cleared and grubbed as stated in paragraph 3-01, and stripped to a depth of 18 inches or as otherwise directed by the contracting officer. The suitable top soil from stripping may be stock piled or placed directly in areas to be top soiled as specified in paragraph 4-08. All other materials from stripping shall be finally disposed of in the excavated portions of the borrow areas. The depths of cuts and lifts and the disposition of the excavated materials may require the contractor to change the locations and depths of his excavating operations whenever such change is, in the opinion of the contracting officer, necessary to obtain the proper quality of material. The excavations shall be worked so that the materials are mixed in the process of excavation. Excavation within the borrow pits shall be in a manner to produce drainage of the material if the ground water table is above the elevation of the excavation. After the excavation is completed, excavated surfaces shall be graded to a smooth and pleasing appearance as directed by the contracting officer and each borrow area shall be so graded that the final surface area shall blend into the surrounding topography and all surface water will readily drain therefrom. (see also paragraph 1-16). The contractor shall construct and maintain all connecting roads required from the borrow areas to the place of disposal.

(b) Stock Piles. - Earth fill materials from stock piles shall be obtained in a manner satisfactory to the contracting officer. The contractor will be required to excavate in the areas directed by the contracting officer and change the locations and depths of excavating operations wherever such a change is directed by the contracting officer. The final surfaces of the remaining part or parts of the stock piles of earth fill shall be graded and blended into the surrounding topography satisfactory to the contracting officer.

Rock materials from stock piles shall be obtained in a manner satisfactory to the contracting officer. After the excavation of the

stock pile of rock is completed, the remainder of the material shall be gathered and neatly piled as directed by the contracting officer.

3-05. CLASSIFICATION OF FOUNDATION EXCAVATION.

(a) Rock Excavation. - All materials required to be excavated which, in the opinion of the contracting officer, cannot be removed by a 2½-cu. yd. power shovel without continuous and systematic blasting, and all boulders and loose rock two cubic yards in volume or greater will be classed as rock excavation.

(b) Common Excavation. - All other material will be classified as common excavation, including boulders and loose rock less than two cubic yards in volume.

3-06. REMOVAL AND DISPOSAL OF FOUNDATION EXCAVATION.

(a) Removal. - All materials shall be removed to the lines and grades as indicated on the drawings, or as otherwise required by the contracting officer, to provide suitable foundations as specified below. (For the limits of each structure listed below see paragraph 1-03 and the drawings forming a part of these specifications).

(1) Excavation for Concrete Structures. - Excavation for the concrete dam section, spillway apron, and training walls, shall be carried to a satisfactory firm foundation as determined by the contracting officer after completion of sub-surface explorations. Areas from which suitable earth materials may be obtained for embankments shall be stripped as directed by the contracting officer. The firm rock line shown on the drawings is only approximate and is not guaranteed. Should actual firm rock be encountered at a higher or lower elevation than the approximate firm rock line shown on the drawings, no change will be made therefor in the contract unit prices.

(2) Excavation for Embankments. - Embankment areas shall be stripped and excavated to lines and grades, and slopes as shown on the contract drawings or as directed by the contracting officer. The contractor shall de-water all excavation areas to produce a dry condition suitable for placing embankment as determined by the contracting officer. Explorations indicate that it will be necessary to remove silt and clay deposits in certain areas for dike foundation. Should excavation be required to a higher or lower elevation than that indicated on the drawings, as determined by the contracting officer, no change will be made therefor in the contract unit prices.

(b) Disposal. - The foundation excavation materials shall be disposed of as follows unless otherwise directed by the contracting officer.

(1) Materials Excavated for Concrete Structures. - All material excavated for the construction of the concrete structures which is suitable, as determined by the contracting officer, for the earth sections of the wing dams and for backfill around the bulkhead sections and behind training walls, shall be placed directly in the earth sections of the wing dams or in stock pile areas approved by the contracting officer. All other material not suitable or in excess of that required for backfill and the embankments of the wing dams shall be disposed of in the spoil areas shown on the contract drawings in a manner and to an elevation satisfactory to the contracting officer.

Rock obtained during the excavation for concrete structures which passes the specifications for Class A and Class B riprap (see paragraph

4-07) shall be placed directly in the rock fill sections of the dike and wing dams (see sheet No. 26) and/or in stock piles. Sufficient rock material shall be placed in the stock piles for riprap on the envelopes at the abutments and the portions of the wing dams which are to be completed after backfilling as stated in paragraph 4-02(d). All rock except shale in excess of that required for the riprap of the embankments and cofferdams shall be deposited on the New York mainland accessible to the access railroad at a place and in a manner approved by the contracting officer. Shale from the foundation excavation shall not be placed in the riprap sections of the embankments but shall be disposed of in the spoil areas shown on the contract drawings or as directed by the contracting officer.

(2) Material Excavated for Embankments. - Material excavated from foundation areas for the embankments (see paragraph 4-01) and determined usable by the contracting officer shall be placed directly in the earth sections of the dike and wing dams in accordance with the specifications stated in Section IV and/or in stock piles. Top soil materials suitable for seeded areas may be stockpiled or placed directly in areas to be topsoiled (see paragraph 4-08). All material excavated and determined waste by the contracting officer shall be placed in spoil areas shown on the plans or as approved by the contracting officer.

3-07. MEASUREMENT AND PAYMENT FOR EXCAVATION.

(a) Measurement.

(1) A survey of the river bed and ground surface for foundation excavation will be made prior to commencement of work and measurements of excavation will be based on this survey and on the classifications specified in paragraph 3-05. Measurement for common excavation will be made between the ground surface and the slope and grade lines shown on the drawings or as modified by the contracting officer, or to the natural rock surfaces encountered in such excavation.

(2) A survey of all borrow areas and earth stock piles will be made prior to the removal of material. Measurement of excavation for embankment materials for payment will be based on this survey, and a final survey of the completed excavation.

(3) Measurement for rock excavation will be made for the actual quantity excavated within the slope, structure, and grade lines shown on the drawings, or such modifications of these lines as directed by the contracting officer. No payment will be made for any rock excavation carried below or beyond these lines by unnecessary drilling and blasting and all rock thus removed, shall be replaced with concrete at the expense of the contractor.

(4) The excavation slope lines shown on the drawings do no represent actual slopes necessary and are not guaranteed by the Government as safe slopes for making the required excavations. The actual slopes required for safety shall be determined by the contracting officer and may be greater or less than shown.

(b) Payment.

(1) Payment for all required foundation excavation shall include the cost of stripping and excavation, transporting and disposal as required under paragraphs 3-01 and 3-06 and will be made at the respective contract unit prices per cubic yard for "Excavation; "Common"; "Excavation; Rock".

(2) Payment for all earth embankment materials excavated from the borrow pits including material stripped from the surface will be made at the contract unit price per cubic yard for "Excavation, Borrow", which unit price shall include all costs of draining, excavating, transporting and dumping the suitable fill material in the embankments; and the stock piling and disposal of the stripping material, and the cost of all operations attendant thereto.

(3) Where stockpiling of suitable common excavation material prior to its incorporation in fill is directed by the contracting officer, separate payment will also be made for excavating from these stockpiles at the rate of 50 per centum of contract unit price for "Excavation; Common"; provided, however, that no payment will be made for stockpiling when and where the contractor is offered the alternative of suspending excavation but elects to stockpile in lieu of suspension. The alternative of suspending excavation will be offered only when and to the extent that in the opinion of the contracting officer progress has been such as to warrant it. Such offer shall not constitute a basis for extension of time limit under the contract. No separate payment will be made for excavating top soil from stockpiles, see paragraph 4-08.

(4) No separate payment will be made for rock excavation from stockpiles, see paragraph 4-07(c).

3-08. FOUNDATION PREPARATION - ROCK. - Foundation excavation for the concrete dam, spillway apron and training walls shall be carried to the lines and grades as indicated on the plans and/or to sound, firm ledge rock, free from open horizontal seams or disintegrated portions. Blasting against surfaces which will form the final surface will not be permitted, see paragraph 3-10. The foundation shall be prepared by barring, picking, wedging, or similar methods which will leave the rock of the foundation in an entirely sound and unshattered condition. The surface of the rock shall be left clean and rough to provide a proper bond between the rock and the concrete. All water shall be removed from the final foundation, which shall be moistened as required by the contracting officer prior to initial placement of grout. The contractor will be required to drill exploratory core holes as described in paragraph 3-12 in the foundation to determine the suitability of the bedrock. Payment for foundation preparation will be included in payment for rock excavation.

3-09. LINE DRILLING.

(a) The vertical rock faces indicated on the drawings or as otherwise required by the contracting officer shall be made with a channeling machine, by drilling and broaching or by close line drilling. Rock excavation adjacent to channeled faces shall be removed in shallow lifts and short sections, and the channeled face remaining shall be of undisturbed rock.

(b) Measurement for line drilling will be made along the vertical surfaces indicated on the drawings or established by the contracting officer. Payment for channeling, drilling and broaching or close line drilling will be made at the contract unit price per square foot of vertical surface for "Line Drilling". Payment for the rock removed will be made as specified in paragraph 3-07.

3-10. BLASTING FOR EXCAVATION. - Blasting will be permitted only when proper precautions are taken for the protection of all persons, the work and property, and any damage done to the work or property by blasting shall be repaired by the contractor at his own expense. Caps or other exploders or fuses shall in no case be stored or kept in the same place in which dynamite or other explosives are stored. All operations of the contractor in connection with the transportation, storage and use of explosives shall be subject to the approval of the contracting officer, and the contractor shall be liable for all injuries or deaths of persons or damage to property caused by blasting or explosives. All necessary precautions shall be taken to preserve the rock outside the lines of excavation in sound condition. Blasting may be done only to the depth, amount and extent approved by the contracting officer. Approval of the method of blasting by the contracting officer, as specified in this sub-paragraph will not relieve the contractor of his responsibility in blasting operation, and no payment will be made for any rock required to be excavated outside of the limit lines indicated on the drawings or below the grade lines established in the field, or modifications thereof directed by the contracting officer, solely due to injury caused by the overshooting, improper blasting or carelessness on the part of the contractor, and all rock thus removed shall be replaced by concrete at the expense of the contractor, including the payment for all cement used in such concrete and furnished by the United States. No blasting shall be done within one hundred (100) feet of concrete which has been in place less than seven (7) days.

3-11. DRILLING EXPLORATORY AND GROUT HOLES.

(a) General. - For the purpose of canvassing bids, the approximate extent of a tentative program for drilling exploratory and grout holes is outlined in these specifications. The Government reserves the right, however, to alter the location and depth of the exploratory and grout holes, and no change will be allowed in the contract unit prices because of such alteration. The contractor shall, at the proper contract unit prices, drill exploratory and grout holes at such locations and at such inclinations not to exceed twenty (20) degrees from the vertical, and to such depths, subject to the limitations hereinafter specified, as may be required by the contracting officer.

(b) Method of Rock Core Drilling. - Core drilling through rock shall be done with standard core drilling equipment using diamond or alloy bits designed to furnish complete standard cores a minimum of 2 inches in diameter from holes 3 inches in diameter. The contractor shall run his drills at such speeds as will insure satisfactory core recoveries, and the contracting officer may require, without compensation, the redrilling of those holes from which the cores are unsatisfactory if the contractor's operations are at fault.

3-12. EXPLORATORY CORE HOLES.

(a) General. - The foundation area covered by the concrete dam and areas adjacent thereto shall, after removing overburden, be further explored by rock core drilling as specified in paragraph 3-11. The layout of holes shall be as directed by the contracting officer. These holes in the foundation rock are intended to determine the location of suitable rock for the foundation of the concrete dam. Concreting shall not be commenced in any section until after the contractor has

received written approval of the foundation for placing concrete for each monolith.

(b) Rock Cores. - Core boxes for storing the 2-inch cores, see paragraph 3-11(b), shall be furnished at the site by the contractor. The cost of the boxes and spacers shall be included in the contract prices. All samples shall be in the custody of the contractor until transported from the site by a representative of the contracting officer, and while in his custody shall be protected. All boxes shall be of pine or similar soft lumber of lightweight, non-warping and capable of holding screws without splitting. They shall be neatly and substantially constructed with suitable partitions, with the top of the box hinged and with suitable hasp fasteners. Partitions in the boxes shall run lengthwise, be securely fastened and shall be approximately 1/8 inch farther apart than the diameter of the rock core to be placed in the box. Spacers to separate the rock core obtained by each run shall be soft wooden blocks to fit between the core box partitions and 1½ inches in length. The core boxes shall be of uniform size 4 feet in length and approximately 12 inches in width, and shall meet with the approval of the contracting officer. All cores shall be neatly arranged in the sequence in which they are removed from the hole, and be properly identified.

(c) Filling with Grout. - All exploratory core holes shall be filled with grout consisting of sand and cement of such mixture as determined by the contracting officer. Sand for grouting shall be as specified in paragraph 3-13(e). The holes shall be filled with grout by means of equipment for pressure grouting as described in paragraph 3-13(d). In filling the exploratory core holes no leakage tests are required and the hole being filled shall not be sealed.

(d) Payment. - All measurements for payment shall be made by or in the presence of an authorized representative of the contracting officer. Holes will be measured for payment for the number of linear feet drilled from the rock surface to the bottom of the hole. Payment will be made at the contract unit price per linear foot for "Drilling 3-inch Exploratory Holes", which payment shall include all work in connection with drilling, core recovery, core boxes, and storage at the site, and for mixing and placing the grout filling. Cement will be furnished by the Government and the sand will be paid for at the contract unit price per cubic foot for "Sand in Grout."

3-13. PRESSURE GROUTING FOUNDATION.

(a) General. - A grout curtain cut-off shall be provided along the upstream section of the dam. This shall be done by pressure grouting a line of holes drilled from the elevation of the grouting gallery or after a minimum of 15 feet of concrete has been placed. All grouting shall be done before the cofferdam controlling the section of the dam being grouted is flooded. The holes through the concrete may be obtained by percussion drilling or by placing 4 inch pipe prior to concreting. The core drilling shall be performed and 2-inch cores recovered as specified in paragraph 3-11. The contracting officer may require approximately 50 percent of the cores from grouting holes to be preserved and stored in core boxes. The core boxes shall be constructed and cores stored as specified in paragraph 3-12(b). Payment for core boxes in which cores from grouting holes are stored will be made as a separate item. The contractor will be required to protect the concrete

surfaces during all drilling and grouting operations and no separate payment will be made for such protection. When the drilling of each hole has been completed, the hole shall be protected from being clogged or obstructed until it is grouted. Any hole that becomes clogged or obstructed prior to grouting shall be opened up to the satisfaction of the contracting officer, and no separate payment will be made therefor.

(b) Pressure Testing. - Before any hole is grouted it shall be pressure tested with water for leakage at intervals of 10 feet throughout the full depth of the hole. The contractor shall furnish the necessary equipment and make the tests. The equipment shall provide capacity sufficient to test the grout holes at pressure up to 150 pounds per square inch. A suitable gage shall be installed in the pressure line at the hole being tested so that pressures in the hole will be indicated at all times. A water meter reading directly to 0.1 cubic foot per minute shall be installed in the pressure line to measure the leakage from the hole. The pressure shall be varied with the depth at the direction of the contracting officer. From the test results, the contractor shall furnish information indicating the location and amount of each leakage. Payment for pressure testing will be included in the contract unit price for "Drilling Foundation Grout Holes in Rock".

(c) Procedure.

(1) The first line of grouting holes shall be drilled at intervals of about 100 feet across the dam foundation as shown on the drawings. The holes shall be drilled and cores recovered, as specified above, to a depth of 100 feet or more as directed by the contracting officer. These holes shall be pressure tested as specified in paragraph 3-13(b) above.

(2) The second set of holes shall be drilled as specified above on 10-foot centers between the first set, and to a depth indicated as necessary by results obtained from the first set of holes and as directed by the contracting officer. The holes on 10-foot centers shall be pressure tested and the leakage measured as specified above.

(3) All the holes on 10-foot centers shall next be thoroughly washed out and grouted according to the procedure specified in paragraph 3-13(e). Should seams connect between any adjacent grout holes these holes shall be interconnected and simultaneously washed and then simultaneously grouted. If more than three holes join any one seam, seals and connections will be required, of a design approved by the contracting officer, to simultaneously grout the holes.

(4) After the grout holes on 10-foot centers have been satisfactorily grouted and not sooner than 48 hours thereafter, test holes shall be drilled midway between and to the same depth as the adjacent 10-foot holes. These test holes shall be drilled, tested, and if found to leak more than approved by the contracting officer, they shall be grouted by the same method as the holes on 10-foot centers.

(5) This method of drilling and grouting shall continue until the grouting has been accepted as completed, i.e., when a hole is drilled and found necessary to grout, holes shall be drilled each side of the grouted hole at one-half the previous interval, and the same testing, washing and grouting procedure shall be followed until no more leakage is observed or as otherwise directed by the contracting officer.

(d) Grouting Equipment to be Used. - The equipment to be used for mixing and injecting the grout shall be subject to the approval of the contracting officer. The grouting unit shall provide:

(1) A grout mixer for mixing the ingredients.

(2) A suitable water meter with straight-reading register reading to the nearest 0.1 cubic foot for measuring the mixing water.

(3) A water tank for auxiliary water supply to be used for pressure testing, flushing pumps, lines, and hole.

(4) A mechanically agitated sump to prevent the segregation of ingredients after mixing and to maintain a supply during the mixing period.

(5) Two duplex piston displacement grout pumps so piped and assembled as to provide interchangeable, continuous, and effective injection of grout at any desired pressure, not to exceed 250 pounds per square inch.

(6) Air compressors of suitable capacity, water pumps, and auxiliary equipment. The mixer and sumps shall each have a volume of not less than 15 cubic feet. The assembled unit shall allow the injection of 150 cubic feet of solids per hour at 150 pounds per square inch pressure, if desired. The grouting equipment shall be maintained in a manner satisfactory to the contracting officer and so as to insure continuous and effective performance during any grouting operation. Circulating grout lines shall be not less than 1½ inches in diameter and are to be controlled by suitable valves in the header and piping so that all or part of the grout can be injected into the hole, or all or part returned to the sump. A suitable pressure gage shall be provided at the hole as well as at the pump for indicating the pressure during the injection of grout. The pressure gage shall be installed in the header near the hole being grouted. Bypassing of the grout back to the sump tank shall be near the hole being grouted and not at the machine. Grout stops or packers and hole connections are to be provided which shall consist of a double sealing unit 5 feet long. The expanding seals at each end shall be composed of rubber and have a length of 6 inches by 3 inches in diameter as directed by the contracting officer. Miscellaneous calking tools and hammers and necessary labor for calking will be furnished by the contractor as directed by the contracting officer.

(e) Composition of Grout and Method of Placement.- Grout shall consist of a mixture of neat Portland cement and water in proportions as directed by the contracting officer, or sand or rock flour may be mixed with grout in proportion not to exceed 1 cement to 3 sand or rock flour. The type and mixture of grout to be used will be determined by the nature of the seams to be grouted and as directed by the contracting officer. Sand, if used, shall be of such fineness that 100 percent will pass a No. 28 standard sieve and 25 percent will pass a No. 100 sieve. Rock flour, if used, shall be dust obtained by crushing dolomite rock and it shall be at least as fine as specified above for sand. Cement for grouting will be furnished by the Government in paper bags, see paragraph 1-10(d). Prior to pressure grouting, all grout holes shall be sounded and, if necessary, shall be thoroughly washed and cleaned with water under continuous pressure or by compressed air and water in a manner which will permit free overflow of waste water, by inserting a smaller pipe and introducing the wash water at the bottom of the hole. The speed of operation of the grout pump and the grouting pressure will be as directed by the contracting officer. In general, it is expected that pressures up to 150 pounds per square inch will be required for the deeper sections of the holes, while lower pressures will be used for the upper zones. Grouting shall be continued until the hole takes the grout mixture at a rate of less than one cubic foot in 10 minutes under the required grouting pressure, and the grouting of any hole shall be discontinued when directed by the contracting officer. The contracting officer may require that the grouting of any holes be temporarily suspended if work is proceeding in an unsatisfactory manner, and the

hole protected by suitable means until grouting is resumed. In the event of an unavoidable delay during grout injection, the contractor shall supply water at not less than the specified grouting pressure for application to the hole as directed by the contracting officer. When the grouting of any hole has been commenced, it shall be continued until completion, unless otherwise directed by the contracting officer. After grouting operations for any hole have been completed and the grout set, or if the rock about any hole is in such sound condition that pressure grouting is not necessary, the hole shall be completely filled with grout. When a hole during the grouting procedure shows back pressure it shall be capped or otherwise sealed.

(f) Measurement and Payment.

(1) Measurement for payment of holes in concrete will be from the plane of entry of the drill at the concrete surface to the bottom of the concrete. Measurement for payment for holes in rock will be from the plane of entry of the drill at the rock surface to bottom of hole. Payment for drilling grout holes in concrete and rock will be made at the contract unit price per linear foot for "Drilling Foundation Grout Holes in Concrete" and "Drilling Foundation Grout Holes in Rock" respectively, which payment shall include drilling, pressure testing, protection of the completed hole and all costs in connection therewith. If the contractor uses 4-inch pipe for the holes through concrete in lieu of drilling he will be paid for such holes as are authorized to be used at the same rate as though the holes were drilled.

(2) Core boxes that may be required to store cores from grout holes will be paid for at the contract unit price each for "Core Boxes", which payment shall include all costs for transporting and storage in connection therewith.

(3) Payment for grouting will be made at the contract unit price per cubic foot for "Pressure Grouting". The volume of grout will be considered to be equal to the volume of cement and sand or rock flour used. This payment shall include washing and jetting of grout holes, and all materials, equipment, and labor necessary, except that cement will be furnished by the United States and sand or rock flour will be paid for separately. No payment will be made for grout lost due to improper anchorage of grout pipes or connections, nor for grout rejected by contracting officer because of the improper mixing.

(4) Payment for furnishing sand or rock flour used in grouting will be made at the contract unit price per cubic foot for "Sand in Grout" or "Rock Flour in Grout".

3-14. FOUNDATION DRAINS.

(a) Drain pipes. - Prior to the placing of concrete, 8-inch black steel pipes shall be set in the foundation at approximately 30-foot centers in vertical or inclined positions not to exceed 20 degrees inclination from the vertical, as shown on the drawings, or as otherwise directed by the contracting officer. Pipes shall be adequately supported during the concreting operations to preserve the required alignment. Covers and drains shall be furnished and installed as shown on the drawings.

(b) Drain Holes. - Drain holes 6 inches in diameter shall be drilled through the drain pipes after foundation grouting has been completed, to depths as directed by the contracting officer, but not to exceed 100 feet below the bottoms of the pipes.

(c) Measurement and Payment. - Payment for furnishing and installing drain pipes including covers will be made at the contract unit price per pound for "Pipe; Black Steel, 8-inch". Payment for drilling drain holes

will be made at the contract unit price per linear foot for "Drilling 6-inch Holes". Payment will be made only for the linear feet drilled below the bottoms of the drain pipes.

3-15. DRILLING 6-INCH CONCRETE CORES.

(a) General. - The contractor shall drill holes in the concrete at such locations and to such depths as may be directed by the contracting officer in order to obtain concrete cores 6 inches in diameter in lengths satisfactory for testing. A tolerance of ¼ inch will be permitted in the diameter of the cores. The contractor shall mark each core with black paint giving location and elevation. Upon completion of drilling, the contractor shall refill the hole with well rodded concrete of the same mix and water content as that from which the core was taken.

(b) Measurement and Payment. - Payment for drilling 6-inch concrete cores and for refilling holes with concrete will be made at the contract unit price per linear foot for "Drilling 6-inch Concrete Cores", for actual core lengths drilled and recovered. The quantity shown in the bidding schedule for "Drilling 6-inch Concrete Cores" is given only for the purpose of canvassing bids and the Government does not guarantee that any of this work will be required or that the quantity will be limited to the amount estimated.

SECTION IV

EMBANKMENTS, BACKFILL, AND PROTECTION STONE

4-01. DEFINITION. - The term "Embankments" as used in this section includes the compacted earth fill of the wing dams and dike; the compacted earth backfil around the bulkhead sections of the concrete dam and behind the training walls; the sand and gravel backing, riprap protection, and filter blankets of the abutment slopes, dike and wing dams; and all other specified or directed fill and slope protection except cofferdam, railroad, and highway fills.

4-02. GENERAL PROVISIONS.

(a) Lines and Grades. - The embankments shall be constructed to the lines and grades shown on the drawings or otherwise required by the contracting officer. The contracting officer reserves the right to change the foundation widths, change the slopes and dimensions of the embankments, change the dimensions and slopes of the foundation cut-off trenches and change the shape and thickness of the dumped riprap protection and make such other changes as future studies and conditions on the work indicate as necessary for the construction of a safe and permanent structure as determined by the contracting officer. Changes in quantities of materials resulting from changes in sections shall be no cause for claims of increased contract unit prices.

(b) Materials.- Materials for the various sections of the embankments shall conform to the respective requirements specified in the following paragraphs of this section. No brush, roots, sod, and perishable or objectionable materials, as determined by the contracting officer, shall be placed in the embankments. Any objectionable material placed in the embankments shall be removed by the contractor as directed by the contracting officer, without cost to the Government. The suitability of each part of the foundation for placing embankment materials thereon and of all materials for use in an embankment will be determined by the contracting officer. No materials shall be placed in an embankment when either the materials or the foundation on which they are to be placed is frozen.

(c) Conduct of the Work.- The contractor shall at all times maintain the embankments in conformity with paragraph 4-04(c) and in a manner satisfactory to the contracting officer until the final completion and acceptance of all work under the contract. The contractor may be required to suspend work at any time when, in the opinion of the contracting officer, satisfactory work cannot be done on account of rain, floods , cold weather, or other unsatisfactory conditions. Any approved embankment material which is lost or rendered unsuitable after being placed in an embankment and before the completion and final acceptance of the work, due to causes that, in the opinion of the contracting officer, are avoidable, or under the control of the contractor, shall be replaced by the contractor in a manner satisfactory to the contracting officer and without cost to the Government. The contracting officer may require the contractor to remove without cost to the Government any material placed by the contractor outside of specified slope lines.

(d) Order of Work. - The contractor shall be required to

organize the work so that suitable rock and earth fill materials obtained from the excavatins for the construction of concrete structures may be placed directly in the portions of the wing dams between the ends on the natural ground and points 150 feet from the top of the excavation slopes for bulkhead sections. After the bulkhead sections of the dam and the training walls are constructed, the backfilling, the abutment embankments, and unfinished portions of the wing dams shall be constructed of materials obtained from stock piles provided as specified in paragraph 3-06(b) or may be excavated from the upstream sections of the abutments.

4-03. PREPARATION OF FOUNDATION FOR EMBANKMENT.

(a) General. - The foundations for the embankments shall be stripped and excavated as specified in Section III. The test pits, stump holes and other excavated areas, depressions and cavities within the limits of the embankment shall be filled with compacted earth as directed by the contracting officer. The earth fill shall be placed in layers, moistened and compacted in accordance with paragraph 4-04. As the fill is brought up, the side slope of the cut or hole shall be scarified, if in the opinion of the contracting officer, it is required, in order to provide a bond between the fill and the original ground material. The sides of all holes shall be broken down if necessary so as to flatten out the slopes, and the hole then filled with approved material and properly rolled or tamped in place. Immediately prior to placing materials in the dike and wing dams, the entire foundation, except areas to be covered by sand and gravel filter, shall be scarified to a depth of 4 inches. A 4-inch layer of embankment material shall be spread and compacted as specified for Class I fill in paragraph 4-04(e). The foundation upon which fill is placed shall be in a suitable dry condition, as determined by the contracting officer.

(b) Measurement and Payment. - Payment for the fills in the foundation areas indicated above, including the spreading, rolling and wetting where required will be made at the contract unit price per cubic yard for "Earth Fill; Compacted". No payment as a separate item will be made for other work necessary for the preparation of the foundation including the dewatering in the foundation areas of the embankments, but the cost of these items shall be included in the contract unit prices for the other items of work connected with the embankments.

4-04. COMPACTED EARTH FILL.

(a) General. - The earth sections of the embankments shall be constructed of Class I and Class II compacted fill as shown on the drawings. The center section of the dike and wing dams shall be composed of Class I compacted fill, rolled and compacted as specified in paragraph 4-04(e) below. Upstream and downstream sections of the dike and wing dams and backfill behind training walls shall be composed of Class II compacted fill, rolled and compacted as is specified in paragraph 4-04(e). Backfill within 50 feet of the bulkheads shall be composed of Class I compacted fill, and beyond 50 feet shall be Class II compacted fill.

(b) Material for the earth fill sections of the embankments including backfill around the bulkhead sections of the dam shall be secured from the designated borrow areas or from stock piles in the

manner specified in paragraph 3-04, from the excavations for the construction of the concrete structures, from excavation necessary for the flattening of the slopes at the abutments, and if directed by the contracting officer, from excavation for the foundation cut-off trenches for the dike. The materials for both Class I and Class II compacted fill in general will be a well graded clayey or silty sand and gravel. No stones which would be retained on a 6-inch screen will be permitted in the Class I compacted earth fill. No stones which would be retained on an 8-inch screen will be permitted in the Class II compacted earth fill. Should stones of such size be found in the otherwise approved earth fill embankment materials, they shall be removed by the contractor. Suitable stones removed may be used for riprap as specified in paragraph 4-07. Each load of material to be placed in the compacted earth fill shall be the equivalent, as nearly as practicable, of a mixture of materials obtained from an approximately uniform s trip or cutting from the full height of a lift in excavation. The combined excavation and embankment placing operations shall be such that the materials when compacted in the fill will be blended sufficiently to secure the greatest homogeneity and desired density.

Any material encountered in the required excavation that meets the requirements of paragraphs 4-05 or 4-06 may be used for the filter or sand andgravel backing as directed. Additional materials required for the filter or sand and gravel backing not obtainable from required excavation shall be obtained from other sources by the contractor.

(c) Placement.- The distribution and gradation of materials throughout the earth fill sections of the embankments shall be such that the embankments will be free from lenses, pockets, streaks or layers of materials differing materially in texture or gradation from the surrounding material. The dumping of successive loads of earth fill materials from the different parts of the borrow pits, stock piles or required excavations shall be at locations in the embankment as directed by the contracting officer, and for this purpose, the contracting officer may direct the points in the embankments where individual loads of material shall be deposited, to the end that the more pervious material shall be placed in the downstream section of the dike and wing dams and in the outer sections of the backfill. After dumping, the materials shall be spread by bulldozers or other approved methods in approximately 8-inch layers over the prepared foundation or fill. Materials within 18 inches of concrete walls and in other areas where compacting by rolling is impracticable as determined by the contracting officer, shall be spread in layers 4 inches in thickness before compacting. All layers shall extend at an approximately uniform elevation over the entire width of the cross section of the embankment and for the entire length of the section under constructinn unless otherwise directed by the contracting officer. The top surfaces of the earth fill sections of the embankments during construction shall be kept crowned with grades not less than 2 nor more than 4 percent, so that the surface of the fill will drain freely toward the slopes. The surface of the fill shall be maintained at all times in such a manner that no water pockets will be formed under any weather conditions. If work is stopped on any part of the Class I compacted earth fill or backfill for a period of time, the area to remain standing shall be rolled with a smooth-faced roller to prevent loss of moisture and to facilitate drainage. If, in the opinion of the contracting officer, the rolled surface of any layer of any section is too smooth to bond properly with the succeeding layer or adjacent section, it shall be

roughened or loosened by scarifying to the satisfaction of the contracting officer before the succeeding layer is placed thereon. Ruts in the surface of any layer shall be filled in a manner satisfactory to the contracting officer.

(d) Moisture Control.

(1) The material in each layer of fill while being compacted shall contain moisture within a few percent of the optimum, as determined by the contracting officer, for the compaction desired. Prior to and during construction, the contracting officer will establish the limiting ranges of moisture contents for materials to be compacted in Class I fill and Class II fill. The moisture content shall be uniform throughout the layer. If the application of water is necessary, it may be done either at the borrow area or at the embankment. Wetting at the excavation area shall be supplemented as required by sprinkling in place on the embankment, if in the opinion of the contracting officer it is necessary. The contractor shall maintain adequate facilities to provide the amount of water required.

(2) No layer of material shall be placed if the moisture content of the exposed surface on which it is to be placed is not within the range established by the contracting officer. The contractor shall correct the moisture content of the compacted layer if the moisture content is not within the required limits.

(e) Compaction.- Class I fill and Class II fill shall be rolled and compacted with the equipment listed in paragraph (f) below. Each layer of Class I fill shall be compacted by not less than 6 passes or trips and each layer of Class II fill shall be compacted by not less than 2 passes or trips of a sheepsfoot roller. In areas within 18 inches of concrete walls and other areas where rolling operations are impracticable, as determined by the contracting officer, compaction shall be obtained with power tampers of a type approved by the contracting officer to give compaction equal to that required for the adjoining compacted earth fill. Each pass of a roller shall overlap the adjacent rolled area by at least 2 feet. If the moisture content is greater or less than that required for compaction, the rolling or tamping shall be delayed until the proper moisture content as determined by the contracting officer has been reached.

(f) Equipment for Compaction by Rolling.- Equipment consisting of an oscillating double section sheepsfoot tamper roller, pulled by a crawler type tractor weighing not less than 20,000 pounds and which is weighted, or equipped with a bulldozer, or both, to increase its total weight to not less than 29,000 pounds, shall be used for compacting the fill. The use of more than 2 rollers in tandem will not be permitted. The design and operation of the compacting equipment shall be subject to the approval of the contracting officer. The speed of the compacting equipment shall be not more than 2½ miles per hour. Each drum of the oscillating double section sheepsfoot tamper roller shall be approximately 4 feet in width and shall have tamping feet uniformly staggered over its cylindrical surface and be provided with cleaners. Each tamping foot shall project approximately 7 inches from the roller's cylindrical surface and at no time during operation shall have a face area lessthan 5 nor more than 7 square inches. The spacing shall be such as to provide not less than 1½ tamping feet for each square foot of cylindrical surface. The sheepsfoot roller shall be weighted so that the total weight of the roller and ballast in pounds divided by the total areas of the maximum number of tamping feet in

one row generally parallel to the axis of the roller shall provide for a range of 250 to 400 pounds per square inch by varying the roller ballast.

(g) Tests for Compaction. - Samples for testing of all materials in the embankments, both before and after placement and compaction, will be taken by the contracting officer at frequent intervals. Corrections, adjustments, and modifications of methods may be required as the result of these tests, for materials, moisture content, or additional compaction of the materials in the embankment. In taking samples for control and record purposes, the contractor shall supply labor required to assist the inspector, as directed by the contracting officer. During the construction of the embankments, it may be necessary for the contractor as directed by the contracting officer to construct test embankments which will form part of the completed fill to determine the number of passes or moisture content necessary to obtain the desired compaction.

(h) Additional Compaction. - If the tests specified above indicate that the desired compaction of the materials in the compacted earth fill sections of the embankments is not secured by the compaction specified in paragraph 4-04(e), additional compaction may be required by the contracting officer. Additional compaction shall consist of making not less than 2 passes of a sheepsfoot roller specified in paragraph 4-04(f) over such designated areas. Each pass of a roller shall overlap the adjacent rolled area by at least 2 feet. This procedure will be repeated as often as is necessary to obtain the desired compaction.

(i) Measurement and Payment.

(1) Measurement for compacted earth fill placed in embankments will be made between the lines indicated on the drawings and the required stripping or excavation lines. Payment for Class I and Class II compacted earth fill will be made at the contract unit price per cubic yard for "Earth Fill; Compacted," which payment shall include all incidental work specified or required such as transporting and spreading, mixing, scarifying, harrowing, moistening, drying, compacting, removing oversize stones and objectionable materials.

(2) Payment for each additional two passes of a roller as required by the contracting officer will be made at the contract unit price per square (100 sq. Ft) for "Additional Compaction".

4-05. FILTER.

(a) General.- Filters shall be constructed at the locations and to the lines and grades shown on the drawings, or at such other locations as may be required by the contracting officer, and shall be placed and compacted the same as for Class II compacted fill. The material shall conform to the requirements specified in the following paragraph and, if practicable during construction, shall be kept to the same height as the adjacent fill material.

(b) Filter Material. - The material for filters shall be well graded sand, or sand and gravel, which after placement, shall contain at least 40 percent by weight which will pass the 1/4-inch mesh screen and no stones shall be larger than 6 inches. Of the material passing the 1/4-inch screen, at least 80 percent by weight shall pass a No. 10 mesh screen, and not more than 10 percent shall pass the No. 200 mesh screen. Samples of the material the contractor proposes to use shall be submitted to the contracting officer at least 30 days prior to the date that the contractor plans to commence placement of filter.

(c) Measurement and Payment.- Measurement of filter material will be made between the lines indicated on the drawings, or as modified by the contracting officer. Payment for furnishing andplacing filter material, regardless of source (see paragraph 1-16) will be made at the contract unit price per cubic yard for "Filter".

4-06. SAND AND GRAVEL BACKING.

(a) General. - Sand and gravel backing for riprap on slopes shall be constructed to the lines and grades shown on the drawings. During construction the placing shall be kept at substantially the same level as the compacted earth fill.

(b) Material.- Material for sandand gravel backing shall consist of bank run sand and gravel of which the material after placement shall contain from 30 to 60 percent by weight retained on the 1/4-inch mesh screen, and no stones shall be larger than 6 inches. Of the material passing the 1/4-inch mesh screen, not more than 20 percent shall pass the No. 200 mesh screen. Samples of proposed material shall be submitted (See paragraph 4-05(b)).

(c) Measurement and Payment.- Measurement of sand and gravel backing material will be made between the lines indicated on the drawings, or as modified by the contracting officer. Payment for furnishing and installing backing material, regardless of source, (see paragraph 1-16) will be made at the contract unit price per cubic yard for "Sand and Gravel Backing."

4-07. RIPRAP.

(a) Classification. - All rock for the riprap protection of the embankments shall be clean, sound, and durable, and as approved by the contracting officer. It shall be obtained from the required rock excavation and earth fill material. Shale and other rock which in the opinion of the contracting officer will not endure frost action shall not be used. Riprap shall be composed of the following two classes of material:

(1) Class A. - Eighty percent of the Class A riprap shall be pieces weighing over 500 pounds and the remainder shall vary with fair uniformity to a minimum weight of 200 pounds. The least dimension of any stone shall be not less than one-third its greatest dimension.

(2) Class B. - This riprap shall consist of rocks weighing in general not over 250 pounds, of which not more tha n 10 percent of the whole shall be formed of pieces weighing lessthan 15 pounds which shall be well distributed throughout the mass.

(b) Placement. - Riprap shall be dumped in the sections to the line and grades shown on the drawings or as directed by the contracting officer. The different sizes of each class shall be well distributed within the section. Care shall be taken in dumping and placing not to disturb the underlying fill. The riprap forming the downstream toe of the dike and wing dams shall be placed in approximately horizontal layers not exceeding 3 feet in thickness as the compacted earth fill progresses, and shall be kept substantially the same level as the compacted earth fill. The dumped riprap on the upstream slope of the dike and wing dams and on the slopes of the abutments may be placed any time during the construction of the embankments providing that, the level of the riprap shall not exceed the level of the compacted earth fill section; any change in the slopes

of the compacted earth fill including slides and washout shall be repaired by the contractor as directed by the contracting officer at no cost to the Government. In the areas where Class B dumped riprap will form the final surface, such hand placing of the finished rock surface will be required as will insure a reasonably smooth and continuous s urface to the slope lines shown on the drawings or as modified by the contracting officer with a tolerance not exceeding plus or minus 9 inches. At the end of a working season for placing compacted earth fill, the dumped riprap sections shall be complete.

(c) Measurement and Payment. - Measurement for riprap in the dumped riprap sections will be made in the embankments between slope lines and grade lines shown on the drawings or as modified by the contracting officer. Payment for the two classes of riprap will be made at the contract unit prices per cubic yard for "Riprap, Dumped; Class A" and "Riprap, Dumped; Class B" which will include payment for excavation from stockpiles, the selection of materials, cleaning, hauling, placing, and all other work required for the completion of the riprap sections in accordance with these specifications.

4-08. SEEDING AND SEEDED TOPSOIL.

(a) Preparation of Seed Bed. - The areas indicated on the drawings or required by the contracting officer shall be covered with topsoil. All other areas to be seeded but not requiring topsoil as directed by the contracting officer shall, prior to fertilizing and seeding, be harrowed or raked until the soil has become loosened and pulverized. All sticks, litter, roots, weeds, stones larger than 1 inch in diameter, and other objectionable materials shall be removed to a depth of 2 inches. Areas requiring topsoil shall be covered with topsoil to a depth of not less than 4 inches after compaction. The topsoil shall be compacted by an approved method. The surface of all seed areas shall be trimmed and raked to conform to finished grades, after which the soil shall be fertilized as specified below. Immediately before sowing the seed, the surface of the seed bed shall be sprinkled, if necessary, and raked to a depth of 3/4 of an inch. The raking shall be done in a direction parallel to the contour lines of the s lopes (not uphill or downhill).

(1) Topsoil. - Topsoil shall be furnished by the contractor from areas approved by the contracting officer (see paragraphs 3-04(a) and 3-06(b)(2)). Topsoil shall be good, rich, dark loam, free from subsoil, gravel, unbroken sod, roots, and refuse. Acceptable topsoil shall be a mixture of sand, silt, and clay particles, and shall contain not less than 5 percent organic matter as determined by loss on ignition of oven dried samples.

(2) Method of Fertilizing. - Prior to seeding, fertilizers shall be uniformly spread in a manner satisfactory to the contracting officer. The seed beds consisting of topsoil shall be fertilized with 1,000 pounds of 20% superphosphate and 300 pounds of sulphate of ammonia to the acre. The seed beds in areas not covered with top soil shall be fertilized with 1,000 pounds of 20% superphosphate and 200 pounds of sulphate of ammonia to the acre. In place of the superphosphate, 330 pounds of T.V.A.metaphosphate to the acre may be used.

(b) Seeding. - The quantity and types of seeds specified below shall be sown on prepared s eed beds in a manner satifactory to the contracting officer. The mixtures shall be sown at the earliest date possible between May 1 and October 1 on areas covered with topsoil, and between

May 1 and September 1 on areas not covered with topsoil. The seed mixtures shall be sown by a mechanical hand seeder or drill. Whenever practical, the mixtures shall be sown in two applications, one-half the seed while the sower is travelling in one direction, and the other half sown while travelling at right angles to the first. The oats or rye shall be sown separately from the remainder of the seed mixture. The domestic rye grass may be sown either separately or mixed with the other seeds. If oats or rye is sown on the surface, the seeds shall be covered by raking to a depth from 1 to 1½ inches. After all the seed is sown, the seed bed shall be lightly raked with iron rakes, and then rolled with a lawn roller in a manner satisfactory to the contracting officer.

(1) Seed Mixtures. - The seed mixtures shall consist of the seeds specified in the tables below. When directed by the contracting officer, the seed mixtures may be varied to suit special conditions of soil peculiar to the areas to be seeded. The seed furnished shall be of the previous year's crop and in no case shall the weed content exceed 1% by weight.

Seed Mixture for Seed Bed of Topsoil

Kind of Seed	%Purity	% Germination	Amount lbs.per acre
Kentucky Blue Grass	98	88	20.0
Creeping Red or Chewing Fescue	97	70	15.0
Canadian Blue Grass	93	85	10.0
Domestic Rye Grass	98	90	10.0
Red Top	90	90	7.5
Kent Wild Clover	97	90	2.0
Ladino Clover	97	90	2.0
Alsike	97	90	3.5
			70.0

Seed Mixture for Seed Bed Not Containing Topsoil

Kind of Seed	% Purity	% Germination	Amount lbs. per acre
Sweet Clover	99	85	5
Alfalfa	98	85	2
Black Medic	95	80	1
Orchard Grass	97	85	3
Timothy	98	85	3
Red Top	98	90	4
Ladino Clover	97	90	1
			19
Oats (Seeding prior to July 15)	99	90	30
Rye (Seeding after July 15)	99	90	35

(2) Inoculation. - The Alfalfa, Black Medic, Alsike, Sweet Clover, Kent Wild Clover, and Ladino Clover Seeds shall be inoculated with pure cultures of nitrogen fixing bacteria. Inoculants shall consist of pure bred soil or sand cultures, not more than one year old, and shall meet the approvalof the New York State Department of Agriculture and Markets. The inoculants shall be mixed with the seed

according to the vendor's instructions. After the mixture is dried, it shall be mixed with the grass seeds. All mixing, drying, and storing shall be done in the shade. The seed mixture shall be applied to the seed bed within 72 hours after the legume seeds are inoculated.

(c) Maintenance and Reseeding. - The contractor shall maintain the areas sown with the above seed mixtures until all work on the contract has been completed and accepted by the contracting officer. The maintenance shall consist of refilling rain-washed gullies, reseeding, mowing, watering during periods of drought, removing in topsoiled areas of large and conspicuous weeds, and other similar operations when required by the contracting officer. The contractor may, if he desires, protect slopes against erosion until seeding becomes established by spreading on the surface about four tons of straw to the acre.

(d) Measurement and Payment. - Measurement for seeding and seeded topsoil will be made by the acre for the area within the line shown on the drawings or as modified by the contracting officer. The contract unit prices shall include payment for all work in connection with furnishing and sowing all necessary seed, raking and rolling the seeded areas, preparing the seed beds, furnishing and placing all necessary fertilizer, and maintaining all seeded areas. Payment for all work in connection with preparing and seeding the seed bed of topsoil, including furnishing, stockpiling, rehandling, transporting, placing, spreading, rolling, and finishing the topsoil, will be made at the contract unit price per acre for "Seeded Topsoil." Payment for seeding all seed beds not of topsoil will be made at the contract unit price per acre for "Seeding."

SECTION V - CONCRETE

5-01 COMPOSITION. - Concrete shall be composed of cement, fine aggregate, coarse aggregate and water so proportioned and mixed as to produce a durable, plastic, workable mixture in accordance with all requirements under this section and suitable to the specific conditions of placement.

5-02. CLASSIFICATION.

(a) Designation. - Except where required to meet special conditions, all concrete shall be Class "A", Class "B", or Class "C" in accordance with the conditions of application and the proportions of materials and strengths required.

(b) Class "A" concrete shall be used for the pierhouse floors, guardhouses, parapets, spillway bridge, and as otherwise indicated on the drawings or directed by the contracting officer.

(c) Class "B" concrete shall be used in the bridge piers, training walls, pierhouse walls, or as otherwise directed by the contracting officer. In general Class "B" concrete will be used in all reinforced portions of the structure not specifically designated as Class "A" or Class "C" concrete.

(d) Class "C" concrete shall be used for the mass section of the dam.

5-03. STRENGTH. - Test specimens of concrete will be 6"x12" or 8"x16" cylinders. Samples will be net-screened to remove aggregate greater than one-fourth the diameter of the test specimen. The mixes will be designed to secure concrete having at least the following compressive strengths at the age of 28 days:

Class	Average for any 25 Consecutive cylinders	Minimum for any one cylinder
A	3400 lbs. per sq. in.	2600 lbs. per sq. in.
B	3000 lbs. per sq. in.	2200 lbs. per sq. in.
C	2400 lbs. per sq. in.	1600 lbs. per sq. in.

5-04. HIGH-EARLY-STRENGTH CONCRETE. - High-early-strength concrete made with high-early-strength Portland cement or other special cements, shall be used only when specifically authorized by the contracting officer. The 7-day compressive strength of concrete of any class, when made with high-early-strength cement, shall be at least equal to the specified minimum 28-day compressive strength for that class using standard cement. All provisions of these specifications, except for cement and aggregates, shall be applicable to such concrete.

5-05. CEMENT AND AGGREGATES. - Cement, and fine and coarse aggregates will be furnished to the contractor by the Government in accordance with paragraph 1-10 of these specifications.

5-06. WATER. - The water used in mixing concrete shall be clean and free from injurious amounts of oil, acid, alkali, or organic matter.

5-07. STORAGE.

(a) Cement.

Immediately upon receipt, at the site of the work, cement shall be stored in a thoroughly dry, weathertight, and properly ventilated building or bin with adequate provisions for the prevention of the absorption of moisture. Storage shall be such as to permit easy access for inspection and definite identification of each shipment.

(b) Aggregates. Each size of aggregate (see paragraph 5-08 (f) shall be stored separately, and in such manner as to avoid the inclusion of any foreign material. The aggregate shall be stored in free draining stock piles or bins for at least 72 hours prior to use. Stock piles of coarse aggregate shall be built in horizontal layers to avoid segregation.

5-08. PROPORTIONING.

(a) Basis. - All concrete materials will be proportioned so as to produce a workable mixture in which the water content will not exceed the maximum specified.

(b) Control. - The exact proportions of all materials entering into the concrete shall be as directed by the contracting officer. The contractor shall provide all equipment necessary to determine, record, and control positively the actual amounts of the various materials, including water, cement, fine aggregate, and each individual size of coarse aggregate, entering into the concrete. The proportions will be changed whenver, in the opinion of the contracting officer, such change becomes necessary to obtain uniformity and workability or the specified strength, and the contractor will not be compensated because of such changes.

(c) Measurement. - All materials shall be measured by weight. One bag of cement will be considered 94 pounds in weight and 1 gallon of water as 8.33 pounds.

(d) Cement Content. - The cement content for each cubic yard of concrete shall generally fall within the following ranges:

Class "A" 5.0 to 6.0 bags
Class "B" 4.0 to 5.0 bags
Class "C" 3.0 to 4.5 bags

For concrete deposited in water, the minimum cement content shall be 6.5 bags or 611 pounds of each cubic yard of concrete placed. The cement content shall be at all times subject to variation as deemed necessary by the contracting officer to attain the desired results.

(e) Water Content and Consistency of Concrete.

(1) In calculating the total water content in any mix, the amount of moisture carried on the surfaces of the aggregate particles shall be included. The total water content per bag of cement for each batch of concrete shall not exceed the following:

Class "A" 5.5 gallons or 45.8 pounds
Class "B" 6.5 gallons or 54.1 pounds
Class "C" 8.0 gallons or 66.7 pounds

In all cases, however, the amount of water to be used shall be the minimum amount necessary to produce a plastic mixture of the strength specified and of the desired density, uniformity and workability. In general, the consistency of any mix shall be that required for the specific placing conditions and methods of placement, and ordinarily the slump shall be between 1/2 inch and 2 inches for Class "B" and Class "C" concrete, and between 1½ inches and

3 inches for Class "A" concrete when tested in accordance with the current specifications for "Method of Test for Consistency of Portland Cement concrete," of the American Society for Testing Materials.

(f) Aggregate Content. - The total volume of aggregates to be used in each cubic yard of concrete shall be that necessary to produce a dense mixture of the required workability as determined by the contracting officer. The individual mixes will be based upon securing concrete having suitable workability, density, impermeability, and the required strength, without the use of an excessive amount of cement.

(1) Coarse Aggregate.

For Class "A" concrete the maximum size aggregate shall be not more than 1½ inches.

For Class "B" concrete the maximum size aggregate shall be not more than 3 inches.

For Class "C" concrete the maximum size aggregate shall be not more than 6 inches.

Specified sizes shall be delivered separately to individual proportioning hoppers in accordance with the following:

a. 3/16" to 3/4"

b. 3/4" to 1½"

c. 1½" to 3"

d. 3" to 6"

(2) Fine Aggregate. - The fine aggregate will consist of natural sand or crushed stone sand, and in either case will be furnished in one size graded so that at least ninety-five percent will pass a No. 4 square mesh sieve.

5-09. MIXING AND PLACING.

(a) Equipment. - The contractor shall provide at the site of the work a modern and dependable batch-type mixing plant with a minimum capacity of 1200 cubic yards of concrete per 8 hours. The plant shall include not fewer than 2 complete mixers of equal capacity with separate power plants. The equipment shall provide adequate facilities for the accurate measurement, record, and control of each of the materials entering the concrete. The complete plant assembly including provision to facilitate the inspection of operations at all times and the adequacy and dependability of each of its parts, shall be subject to the approval of the contracting officer, and shall conform to the following requirements:

It shall be capable of ready adjustment for compensating for the varying moisture content of the aggregates and for changing the proportionate batch weights.

It shall be capable of controlling the delivery of each material to within 1 percent by weight of the designated amounts.

It shall be arranged to permit the convenient removal of material in excess of the specified tolerances, and acceptable facilities shall be provided for readily obtaining representative samples from the batches for test purposes.

Each weighing unit shall include a visible springless gage which will register the scale load at any stage of the weighing operation from zero to full capacity.

Insofar as practicable, each dial and water-measuring device shall be in full view of the operator and the weighing equipment shall be arranged so that the operator may conveniently observe the operation of the bin gates and also the materials discharged into the mixer hopper.

The accuracy of the weighing equipment shall conform to the requirements of the U. S. Bureau of Standards. The contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device and shall make periodic tests, in the presence of a Government inspector, in such a manner and at such intervals as may be directed by the contracting officer; provided, that unless otherwise directed by the contracting officer, such check tests of equipment in operation shall be made at least once every two weeks. After completion of such check tests the contractor shall make such adjustments, repairs, or replacements as the contracting officer may consider necessary to secure satisfactory performance.

The plant shall include a device for accurately measuring and indicating the quantity of water entering the concrete and the operating mechanisms must be such that leakage will not occur when the valves are closed. The filling and discharge valves for the water tank shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed.

It shall include a device for accurately and automatically measuring and indicating the time of mixing, which shall be interlocked to prevent the discharge of concrete from the mixer before the expiration of the mixing period.

It shall include a device for recording and indicating the number of batches handled.

Each set of units for measuring cement and mixing water delivered to one or more mixers shall be provided with an accurate combined autographic recorder for making a continuous visible record on a single chart of the measurement of all materials introduced into each batch, and of the consistency of the concrete during the mixing process. The recorder shall be housed completely, shall be capable of being locked, and shall be placed in a position convenient for use by the plant operator. The recorder paper furnished shall be ruled and printed so that each graph will be identified permanently and so that quantities and time may be read without scaling or calculation. Suitable means shall be provided to insure proper alignment, rate of travel, and tautness of the paper without wrinkling. The recording equipment shall include facilities for automatically registering on the chart the time of day at intervals of not more than 15 minutes and shall be designed for simplicity in operation and maintenance.

Each mixer shall be equipped with an efficient recording consistency meter or provided with eqully suitable equipment or means satisfactory to the contracting officer for indicating concrete consistency and recording it on the combined autographic recorder chart. The sensitivity and range of the consistency meters shall be such that the effect of a change in slump of one inch shall be readily discernible to the operator, as determined by the contracting officer. The contractor shall furnish satisfactory evidence that the consistency meters which he proposes to use are adapted to the type of drum and loading of the mixers with which they are to be used. If the mixers are provided with consistency meters operating on the principle of measuring electrical input to the mixer motors, adequate means shall be provided for eliminating errors due to operating the motor from a variable-voltage supply source, with resultant changes in motor input which are not caused by changes in concrete consistency. If the contractor proposes to use means for the partial elimination and compensation of these errors, such means shall be subject to the approval of the contracting officer and

the residual errors shall not exceed one percent of the values being measured. Errors in registration of concrete consistency caused by variable friction in the mixer equipment shall be eliminated or minimized by providing adequate antifriction bearings and lubrication or by other means satisfactory to the contracting officer. All graphic charts recorded in accordance with this paragraph shall become the property of the Government.

(b) Mixing Time. - The minimum time for mixing each batch, after all materials are in the mixer, shall be as follows:

1/2-cubic yard mixer, or smaller	1¼ minutes
3/4- to 1½-cubic yard mixer	1½ minutes
1½- to 3-cubic yard mixer	2 minutes
Larger than 3-cubic yard	2½ minutes

The mixer shall revolve at a uniform speed, a minimum of 12 revolutions per minute after all materials have been placed in it. Neither speed nor volume capacity of the mixer shall exceed those recommended by the manufacturer. Excessive overmixing, requiring additions of water to preserve the required consistency, will not be permitted. Should any mixer at any time produce unsatisfactory results its use shall be promptly discontinued until it is repaired or replaced.

(c) Conveying. - Concrete shall be conveyed from mixer to forms as rapidly as practicable, by methods which will prevent segregation or loss of ingredients. It shall be deposited as nearly as practicable in its final position. Chutes used shall be such that the concrete slides in them and does not flow. Chutes with a flatter slope than 1 on 2 will not be permitted. There shall be no free vertical drop greater than 5 feet except where specifically authorized by the contracting officer.

Methods of conveying concrete to any part of the structure by which the concrete is loaded into chutes, belt conveyors, or other similar equipment and carried in a thin, continuously exposed flow, to the forms, will not be permitted except for very limited or isolated sections of the work, and then only when approved in writing by the contracting officer.

Placing of concrete in the dam shall, in general, be done by means of bottom-dump buckets of sufficient size to handle the full capacity of one mixer. The design of the buckets shall be subject to the approval of the contracting officer, and shall be such as to permit close regulation of the amount of concrete to be deposited in each dumping position. It is contemplated that the full capacity of a bucket may be deposited in one operation where this has no objectionable effect on the placement of concrete, but near forms and around embedded items or elsewhere as directed by the contracting officer, the discharge shall be controlled so that the concrete may be effectively compacted into layers not exceeding 18 inches in thickness with a minimum of lateral movement and accompanying tendency for segregation and the formation of rock pockets.

(d) Placing.

(1) Concrete shall be placed before initial set has occured, and, unless otherwise authorized by the contracting officer, before it has contained its water content for more than 30 minutes.

(2) Concrete when deposited in the forms shall have a temperature of not less than 40 degrees F. and not more than 75 degrees F. However, when the temperatures of the materials are such that the temperature of the fresh mixed concrete is 55 degrees or more, the mixing water shall be cooled to a temperature of 35 degrees F., and only aggregates taken from the coolest portions of the stockpiles shall be used. Any heating, cooling, refrigerating, or other operations necessary in order to produce a concrete having a temperature within the above specified temperature limits (40 degrees F. to 75 degrees F.) shall be done by the contractor and the cost thereof

shall be included in the unit prices bid in the schedule for the various classes of concrete.

(3) Unless otherwise specified, all concrete shall be placed in the dry upon clean, unfrozen, damp surfaces, free from running water, and never upon soft mud, dry porous earth, or upon fills that have not been subjected to approved rolling or tamping until optimum compaction has been obtained.

(4) Rock surfaces upon which concrete is to be placed shall be approximately horizontal or stepped, and shall be clean, solid, and free from oil, running water, mud, objectionable coatings, debris and loose, semi-detached, or unsound fragments and shall be sufficiently rough to assure satisfactory bond with the concrete. Immediately before concrete is placed, all such rock surfaces shall be cleaned thoroughly by the use of high velocity air-water jets, wet sandblasting, stiff brooms, picks, or other effective means satisfactory to the contracting officer. All pools of water shall be removed from depressions in order to insure proper bonding of the fresh concrete to the rock surfaces and no inflow of water into the foundation will be permitted. All necessary installations of riser pipes, headers, sand drains, and other installations necessary to produce a foundation free of running or standing water shall be installed by the contractor and so welded or otherwise securely fastened in place as to prevent their being jarred loose by concrete placement. No separate payment will be made for such installations. No wooden plugs or other organic materials will be placed permanently in any foundation. All absorptive surfaces shall be thoroughly wetted for 48 hours and spread with a layer of mortar about 1/2 inch thick immediately before the concrete is placed. The mortar shall be of the same cement-sand ratio as used in the concrete.

(5) The layout of all monoliths shall be as shown on the drawings or as directed or approved by the contracting officer before concreting is commenced.

(6) All concrete shall be deposited in approximately horizontal layers, unless otherwise specifically authorized or directed by the contracting officer, and the concreting shall be carried on as a continuous operation, as far as practicable, until the placing in the course, section, panel or monolith is completed. Concrete must be covered within 45 minutes to one hour, depending on cement used, with fresh concrete during one pour. Lifts of mass concrete in the dam and training walls shall not exceed 5 feet in thickness except as shown on the drawings, and a minimum of 120 hours shall elapse between the finishing of one such lift and the starting of the next. In general a minimum of 24 hours shall elapse for each foot of thickness between the finishing of one lift and the starting of the next. The first two to four lifts starting from the foundation and from lifts which have been in place longer than 15 days shall be limited to a maximum height of 2 to 3 feet; as determined by the contracting officer.

Other lifts shall generally have a minimum thickness of 4 feet, and a maximum thickness of 12 feet. In walls of buildings, lifts shall terminate at the tops and bottoms of the door and window openings.

(7) In dropping concrete through reinforcement, care shall be taken than no segregation of the coarse aggregate occurs. On flat surfaces where the congestion of steel near the forms makes placing difficult, a mortar of the same cement-sand ratio as is used in the concrete shall be first deposited to cover the forms.

(8) All top surfaces not covered by forms and which are not to be covered by additional concrete or backfill shall be carried slightly

above grade and struck off by board screed (see paragraph 5-11 (a)), except that top surfaces of walls and piers not covered by forms and which are not to be covered by additional concrete or backfill when poured in excess of 10 feet in height in one pour, shall be carried not less than 2 inches above the specified finished elevation and struck off by board screed.

(e) Vibrating. - Concrete shall be placed with the aid of mechanical vibrating equipment as approved by the contracting officer.

(1) Internal vibrators shall be used in all sections 10-inches or more in width or which are sufficiently large to accomodate them. External vibration shall be used when directed by the contracting officer as auxiliary to internal vibration.

(2) Vibrators shall be of sturdy construction, adequately powered and capable of transmitting to the concrete not less than 5,000 impulses per minute when operating under load(immersed in concrete). The frequency of vibration shall be subject to proof by measuring the impulses radiated by the vibrator, when operating in concrete designed for the project, by the use of a Frahm vibrating-reed tachometer or equal. The vibration shall be sufficiently intense to cause the concrete to flow or settle readily into place and show a visible effect over a radius of at least 18 inches in the concrete.

(3) A sufficient number of vibrators shall be employed so that, at the required rate of placement, vibration throughout the entire volume of each layer of concrete and complete compaction are secured. At least one extra vibrator shall be constantly on hand at each point of placement (monolith) for emergency use.

(4) Form vibrators, where used, shall be attached to or held on the forms in such a manner as to transmit the vibration to the concrete effectively and shall be raised in lifts as filling of the forms proceeds, each lift being not more than the height of concrete visibly effected by the vibration. They shall be placed horizontally at distances not greater apart than the redius through which the concrete is visibly affected.

(5) Internal vibrators shall be kept constantly moving in the concrete and shall be applied at points uniformly spaced not farther apart than the radius over which the vibrator is visibly effective. The vibrator shall not be held in one location long enough to draw a pool of grout from the surrounding concrete. Internal vibrators shall be applied close enough to the forms to vibrate the surface concrete effectively, but care shall be taken to avoid hitting the forms sufficiently to damage them.

(6) The vibration shall be such that the concrete becomes uniformly plastic and there shall be at least 10 seconds of vibration per square foot of surface of each layer of concrete, computed on the basis of the visibly affected radius, and taking overlapping into consideration.

(7) Vibration shall be supplemented by forking and spading by hand adjacent to the forms on exposed faces. The concrete shall be compacted and worked in an approved manner into all corners and angles of the forms and around reinforcement and embedded fixtures.

(f) Construction Joints. - Vertical joints shall be formed with tongue-and-groove keys at such locations and of such shapes and dimensions as shown on the drawings or as approved or directed by the contracting officer. Horizontal joints shall be continuous throughout all monoliths to produce continous horizontal lines on the faces of the dam. The horizontal edges of each completed pour not required to be chamfered that are exposed to weathering shall be struck off level for a distance of about 6 inches

back from the form to provide an even and neat appearance between construction joints. Where required, dowel rods shall be used.

All concrete in vertical members shall have been in place not less than 12 hours, and longer if so directed by the contracting officer, before concrete in horizontal members resting thereon is placed.

After the top surface of a course is finally compacted, it shall be thoroughly protected from pedestrian traffic, materials being placed thereon, running water, or any activity upon the surface that might in any manner affect the initial setting of the concrete for a period of 4 to 20 hours as determined by the contracting officer. After the time required for initial set, the surface shall be washed with a high pressure air (air pressure capacity not less than 100 p.s.i.) and water jet to remove all laitance and to expose clean young aggregate.

Immediately before placing is resumed in each succeeding course, all approximately horizontal construction joint surfaces shall be washed with a high pressure air and water jet and scrubbed with steel brushes and brooms. Sand shall be added to the air-water jet when required to remove algae, stains and other substances injurious to bonding. After final cleaning and immediately before placing is resumed the surface shall be wetted and spread with a layer of mortar 1/2 inch thick. The mortar shall be of the same cement-sand ratio as the concrete.

Where fresh concrete is to be placed against smooth surfaces of previously placed concrete, the surface of the previously placed concrete shall be roughened by picking, or other means approved by the contracting officer, in order to secure adequate bond. No payment will be made for such roughening but the cost shall be included in the contract unit price for the class of concrete affected.

(g) In water. - When specifically authorized, concrete may be deposited in water having a temperature above 35 degrees F. The methods and equipment used shall be subject to the approval of the contracting officer. When deposited by the tremie method, the tremie shall be watertight and sufficiently large to permit a free flow of concrete. The discharge shall be kept continuously submerged in the concrete and the shaft kept full of concrete to a point well above the water surface. When the bottom-dump bucket method is used, the bucket shall not be dumped until after it has come to rest on the surface upon which the concrete is to be deposited. The bucket shall be provided with a suitable cover, and the bottom doors, when tripped, shall open freely. The bucket shall be completely filled and slowly lowered in order to avoid backwash, and when tripped, it shall be slowly withdrawn until entirely free of the concrete. With either method, concreting shall proceed without interruption until the top of the concrete is well above the water surface.

(h) Cold Weather. - Concrete shall not be placed when the ambient atmospheric temperature is below 35 degrees F. nor when the concrete is likely to be subjected to freezing temperatures before final set has occurred, unless specifically authorized by the contracting officer in writing. When so authorized, the materials shall be heated in such a manner that they will be free of ice, slush, snow, frozen lumps, etc., before entering the mixer. The temperature of the concrete when deposited in the forms shall be within the limits specified in paragraph 5-09 (d)(2). All methods and equipment for heating shall be subject to the approval of the contracting officer.

(i) Hot Weather. - For concrete placed during the extremely warm summer months and otherwise, when directed by the contracting officer, the

contractor shall take whatever measures are necessary in order to produce a concrete having a temperature below the maximum limit specified in paragraph 5-09 (d)(2). The methods and equipment used shall be subject to the approval of the contracting officer.

5-10. TEST SPECIMENS.

(a) Number. - Test specimens, to determine whether the compressive strength of the concrete is in accordance with that specified in paragraph 5-03, will be taken by the Government inspector. At least 1 set of 3 specimens will be made for every major placement and, in general, for every 500 cubic yards of concrete placed, but in any event, a sufficient number of specimens will be taken to give a comprehensive knowledge of the concrete in each section of the work.

(b) Method. - All specimens will be taken from the concrete in accordance with the current specifications of the American Society for Testing Materials. The specimens will be tested by and at the expense of the United States, either in its laboratory or in that of a recognized commercial testing agency.

5-11. FINISHING.

(a) General. - Immediately after placement, the concrete shall be properly forked back along the faces of all forms by the use of concrete forks or spades and then re-vibrated unless otherwise specifically authorized or directed by the contracting officer. The surface of concrete finished against forms shall be smooth, dense, and free from rock pockets. Immediately upon the removal of forms, all unsightly ridges or lips shall be removed and undesirable local bulging on exposed surfaces shall be remedied by tooling and rubbing to the satisfaction of the contracting officer; all holes left by the removal or omission of tie rods, and all similar voids unless otherwise directed by the contracting officer shall be neatly filled with cement mortar mixed in the same proportions as the original mix, provided that whatever practicable mortar which has been mixed and allowed to stand for one hour shall be used and placed as directed by the contracting officer. Defective concrete shall be repaired by cutting out the unsatisfactory material and placing new concrete which shall be formed with keys, dovetails, or anchors to attach it securely to the other work. This concrete shall be drier than the usual mixture and shall be thoroughly tamped into place. All finishing, tooling, rubbing and filling of the rod holes and all patching of exposed surfaces must be performed immediately after forms are removed and the succeeding course of concrete shall not be placed until the exposed surfaces of the preceding lifts have been finished to the satisfaction of the contracting officer. All surfaces of concrete, not covered by forms, that are not to be covered by additional concrete or backfill, shall have a wood float finish without additional mortar, and shall be true to elevations as shown on the drawings. Care shall be taken to see that all excess water is removed before making this finish. Other surfaces shall be brought to the specified finished elevation and left true and regular as approved by the contracting officer. Where considered necessary by the contracting officer, or where indicated on the drawings, joints shall be carefully made with a jointing tool. Every precaution shall be taken by the contractor to protect finished surfaces from stains or abrasions. No fire shall be permitted in direct contact with any concrete at any time. Concrete surfaces, or edges likely to be injured during the construction period, shall be properly protected by leaving

the forms in place, or by erecting covers satisfactory to the contracting officer.

(b) Floor Surfaces. - Unless otherwise specified, all floors and other surfaces where indicated on the plans or required by the contracting officer, shall be finished with a 1-inch monolithic sand-cement mortar surface. All water, laitance and any foreign matter shall be removed from the surfaces. The topping mixture shall be spread evenly over the base within 45 minutes after the base has been placed. The mortar shall be of 1 part cement and 3 parts approved clean sand. The cement and sand shall be thoroughly mixed dry and then sufficient water shall be added to produce a medium stiff mortar. After placing, the mortar shall be floated to a true, regular surface with a wood float and steel-troweled to a smooth finish. Troweling shall be the minimum amount consistent with obtaining a smooth dense surface and shall not be done until the mortar has hardened sufficiently to prevent excess fine material from being worked to the surface.

5-12. CURING.

(a) General. - Before actual concrete placement begins, the contractor shall have on hand and ready to install all equipment needed for adequate curing and protection of the concrete.

(b) Warm Weather. - All concrete shall be adequately protected from injurious action by the sun. Fresh concrete shall be protected from heavy rains, flowing water, and mechanical injury. All concrete shall be kept wet for a period of not less than 14 days by covering with water, or with an approved water-saturated covering or by a system of perforated pipes or mechanical sprinklers, or any other approved method which will keep all surfaces continuously (not periodically) wet. Where wood forms are left in place for curing, they shall be kept wet at all times to prevent opening at the joints and drying out of the concrete. Water for curing shall conform to the requirements of paragraph 5-06, and shall be generally clean and entirely free from any elements which, in the opinion of the contracting officer, might cause staining or discoloration of the concrete.

(c) Cold Weather. - Concrete when placed during cold weather shall be kept moist and provided with adequate protection, subject to the approval of the contracting officer, so that the air in contact with the concrete will be maintained at temperatures between 50 degrees F. and 70 degrees F. for at least the first 5 days. For massive section, where the atmospheric temperatures are sufficiently low, in the opinion of the contracting officer, to cause excessively rapid cooling and contracting of the exterior surfaces, the period for maintaining the temperature of the air in contact with the concrete between 50 and 70 degrees F. may be required to extend for 14 days. In extremely cold weather, the removal of temperature protection shall be done gradually so that the temperature of the air surrounding the concrete is reduced to the outside air temperature at a rate not faster than 5 degrees F. in any one hour, or 50 degrees F. in any 24 hour period. Salt or other chemicals shall not be admitted into the mixture to prevent freezing.

5-13. FORMS.

(a) Materials. - Forms shall be of wood, steel or other approved material, except that the sheeting for all exposed surfaces shall be tongue-and-groove lumber of uniform width unless otherwise specifically authorized. Forms of like character shall be used for similarly exposed surfaces in order to produce a uniform appearance. The type, size,

shape, quality and strength of all materials of which the forms are made and the design of the forms shall be subject to the approval of the contracting officer.

(b) Construction. - Forms shall be built true to line and grade, and shall be mortar-tight and sufficiently rigid to prevent displacement or sagging between supports. Where forms for continuous surfaces are placed in successive units, care shall be taken to fit the forms tightly over the completed surface so as to prevent leakage of mortar from the concrete and to maintain accurate alignment of the surface. Responsibility for their adequacy shall rest with the contractor. Their surfaces shall be smooth and free from irregularities, dents, sags, or holes when used for permanently exposed faces. Bolts and rods used for internal ties shall be so arranged, that, when the forms are removed, all metal will be not less than 2 inches from any concrete surface. Bolt holes shall be reamed with a suitable toothed reamer so as to leave the surfaces of the holes clean and rough and shall be filled with mortar as specified in paragraph 5-11 (a), immediately upon removal of the forms. Wire ties will not be permitted without the approval of the contracting officer, and at no time where the concrete surface will be exposed to weathering and where discoloration will be objectionable. All forms shall be so constructed that they can be removed without hammering or prying against the concrete. Unless otherwise indicated, suitable moldings shall be placed to bevel or round exposed edges, at expansion joints and/or any other points as may be required by the contracting officer.

(c) Coating. - Forms, except those lined with absorptive form lining, shall be coated with a non-staining mineral oil which shall be applied shortly before the concrete is placed.

(d) Removal. - Forms shall not be removed without the approval of the contracting officer, and all removal shall be accomplished in such manner as will prevent injury to the concrete. Forms shall not be removed before the expiration of the minimum number of days indicated below, except when specifically authorized by the contracting officer. When, in the opinion of the contracting officer, conditions on the work are such as to justify it, forms may be required to remain in place for longer periods.

Arches, beams and slabs	14 days
Columns	7 days
Walls and vertical faces	2 days

(e) Absorptive Form Lining. - In addition to the requirements for work specified above, the forms for all permanently exposed surfaces, including the spillway apron, the upstream and downstream faces of the dam and the training walls, not covered by backfill; bridge piers, parapet, spray walls, pierhouses, guardhouses, and galleries through the dam shall be constructed of matched lumber, approved by the contracting officer, and lined with absorptive lining. The absorptive form lining shall be capable through its absorptive capacity of eliminating voids, pits and other common defects from the surface of the concrete placed against it. The form lining shall be highly absorptive to air and water and shall possess surface characteristics such as will result in a dense concrete with a satisfactory surface texture, and the minimum amount of sticking of the lining upon removal of the forms. The lining shall be readily adaptable to cutting, fitting and any other operation necessary in connection with its use. The lining itself, and any coating or treatment employed in its manufacture, shall be such as will not create discoloration or interfere with the normal chemical reactions of the cement in the concrete. The type of lining shall be subject to the approval of the contracting officer. Tests

shall be made by the contractor of all proposed absorptive lining as directed by the contracting officer. These tests shall include the use of absorptive form lining on concrete surfaces in the dam which will be later covered by backfill. Samples shall also be furnished to the Government for laboratory tests, before approval of any type of lining by the contracting officer. Horizontal joints will not be permitted in absorptive form lining except at horizontal construction joints in the concrete unless otherwise directed or approved by the contracting officer. Other joints in absorptive form lining shall be made only where directed or approved by the contracting officer. For cutting and trimming the absorptive lining, the contractor shall use tools which are well adapted for this work and are maintained in such condition that smooth edges will be produced. The joints between the sheets of absorptive form lining shall be fitted smoothly and accurately, and patching of the sheets of absorptive form lining will not be permitted. At joints, the edges of the form lining shall be in contact but shall not be pressed tightly together. Absorptive form lining shall be attached to the forms with only a sufficient number of nails or other means to hold the lining snugly in contact with the surface of the forms, and free from bulges and other imperfections that might cause unevenness or roughness of the concrete surfaces. Nails shall be driven so that the under side of the nail-heads will be flush with the surface of the absorptive lining, and care shall be taken not to make dents in the surface of the lining with hammers or in any other manner. After the absorptive lining has been nailed in place, the joints shall be rubbed with a smooth tool to make the joints smooth and to press down any projecting fibers. In tightening the form anchors where absorptive form lining is in contact with the face of a previous lift, sufficient pressure shall be applied to compress the lining at the surface of contact so as to compensate for the reduction in thickness of the lining not in the surface of contact which will be caused by the pressure of the freshly placed concrete. Insofar as practicable, the contractor shall avoid splashing mortar or concrete on the absorptive lining and shall remove, without damage to the lining, such coatings as have set or become dry before the concrete is placed against the lining. Absorptive form lining of fibrous materials shall be used only once unless it can be demonstrated, to the satisfaction of the contracting officer, that re-use is practicable. After use, form lining shall be removed from the site of the work or disposed of as approved by the contracting officer. Forms lined with absorptive lining shall, in general, be removed or loosened early enough to avoid difficulty from sticking; except, the form shall be allowed to remain in place for a sufficient length of time to provide adequate support for the concrete, as determined by the contracting officer. Fibers from the lining which adhere to the concrete when the forms are removed, shall be removed without damage to the concrete, by brushing or other suitable means, as approved by the contracting officer. At all times subsequent to delivery of the absorptive form lining and prior to the placing of concrete against the lining, the contractor shall take all precautions necessary to protect the lining from becoming damp or wet to such an extent as to damage the material or to reduce its effectiveness as an absorptive medium. Particular care shall be exercised to protect absorptive form lining during clean-up operations, and temporary protection of such lining will be required. The use of absorptive form lining which has become wet or which contains visible external defects such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances or indentations, will not be permitted.

5-14. PLACING STEEL REINFORCEMENT.

(a) General. - All reinforcing steel called for on the drawings or authorized by the contracting officer will be furnished to this contractor by the Government, (see paragraph 1-10). The contractor shall unload and place all steel reinforcement, including rods, fabric and structural shapes as indicated on the drawings or otherwise required. The contract unit price for "Steel Erection; Concrete Reinforcing," shall include unloading, hauling to site, cleaning, proper storage and straightening, if necessary. All reinforcement shall be, when surrounding concrete is placed, entirely free from loose scale, dirt, grease or other coating which might destroy or reduce its bond with the concrete. All placing shall be in accordance with drawings furnished or approved by the contracting officer.

(b) Cutting and Bending. - Steel reinforcement will be mill bent. Miscellaneous bending that may be required at the site shall be in accordance with standard approved practice and by approved machine methods. Bar lists and bending schedules will be as shown on the drawings.

(c) Quality. - The steel reinforcing shall conform to the requirements of paragraph 9-05.

(d) Minimum Spacing of Rods. - The spacing of rods shall be as indicated on the drawings and the clear distance between parallel rods shall not be less than 1½ times the diameter of round rods, or twice the side dimensions of square rods, but in no case shall the clear spacing between the bars be less than 1½ times the maximum size of the coarse aggregate used in the concrete, unless specifically authorized by the contracting officer.

(e) Relation of Rods to Concrete Surfaces. - Except where otherwise indicated, reinforcement shall be placed as follows:

(1) All main reinforcement in massive concrete sections shall be placed not less than 4 inches from any concrete surface, unless otherwise specifically indicated or authorized.

(2) All main reinforcement in walls and slabs of buildings exposed to the weather and in fire-resistent construction, shall be placed not less than 1 inch from the surface in walls and slabs, 1½ inches in floor beams, and 2 inches in girders and columns. In interior flat slab construction, the minimum cover may be reduced to 3/4 inch. For interior work where fire hazard does not exist, the main reinforcement shall be placed not less than 3/4 inch from the surface in walls and slabs, 1 inch in floor beams, and 1½ inches in girders and columns.

(3) The covering of stirrups, spacer rods, and similar secondary reinforcement may be less than the above dimensions by the diameter of such rods. The above dimensions shall be measured from the face of the reinforcement to the face of the forms.

(f) Splicing. - Where splices in reinforcement, in addition to those indicated on drawings or directed by the contracting officer, are necessary, there shall be sufficient lap to transfer the stress by bond. Rods shall be lapped not less than 40 diameters and splices shall be staggered. The lapped ends of rods shall be separated sufficiently or connected properly to develop the full strength of the rods. Adjacent sheets of mesh reinforcement shall be spliced by lapping not less than 6 inches, the lapped ends being securely wired together. The expense caused by any laps other than those indicated on the drawings or directed to be placed by the contracting officer, which are provided for the convenience of the contractor, shall be borne by the contractor.

(g) Supports. - All reinforcements shall be secured in place, true to the lines and grades indicated, by use of metal or concrete supports,

spacers or ties as approved by the contracting officer. Such supports shall be of sufficient strength to maintain the reinforcement in place throughout the concreting operation, and shall be used in such a manner that they will not be exposed on the face of, nor in any way discolor nor be noticeable in the surface of the finished concrete. The cost of furnishing and placing all supports, spacers, ties and/or other devices required for reinforcement shall be included in the contract unit price for "Steel Erection; Concrete Reinforcing."

(h) Protection for Future Use. - Exposed reinforcement intended for bonding with future work shall be protected from corrosion by heavy wrapping of burlap saturated with bituminous material.

5-15. EMBEDDED ITEMS.

(a) Before placing concrete, care shall be taken to determine that any embedded metal or wood parts are firmly and securely fastened in place as indicted. They shall be thoroughly clean and free from coating, rust, paint, scale, oil, or any foreign matter. The embedding of wood in concrete shall be avoided whenever possible, metal being used instead. If wood is allowed, it shall be thoroughly wetted before the concrete is placed. Any air or water lines or other materials embedded in the structure as construction expedients shall conform to the above requirements and upon completion of their use shall be backfilled with concrete or grout as directed by the contracting officer. No payment will be made for such items nor for backfill of the items.

(b) For the placement of structural steel in piers, see Section VII.

5-16. EXPANSION AND CONTRACTION JOINTS.

(a) General. - Expansion and contraction joints shall be constructed at such points and of such dimensions as may be indicated or required. The method and materials used shall be subject to the approval of the contracting officer and the materials shall conform to Federal Specifications wherever applicable. In no case shall corner protection angles or other fixed metals embedded in the surface of the concrete and bonded be continuous through an expansion joint.

(b) Built-up Joint Filler. - Joints between dam monoliths shall contain a built-up joint filler where indicated on the drawings and as described below unless otherwise directed by the contracting officer: the area of the joint between the metal water stop and the upstream face of the dam; areas of the joint between the surfaces of the galleries and the surrounding metal water stops; and in other places, a strip 18 inches wide adjacent to final exposed surfaces. The filler shall consist of one thickness of 30 lb. asphalt-saturated roofing felt (see paragraph 9-32), joined to the concrete on each face of the joint by a uniform trowelled layer of bituminous cement Type "B" (see paragraph 9-20(a)).

(c) Preformed Joint Filler. - Preformed joint filler shall be used in the expansion joints of the parapet railing, the upstream gantry girder, the vertical joints between the parapet piers and the sidewalk, and elsewhere as indicated on the drawings or otherwise required by the contracting officer. It shall be nonextruding and resilient preformed expansion joint filler conforming to type II, self-expanding cork, of Federal Specification HH-F-341, and shall be 1 inch thick as indicated on the drawings. Pieces of the joint filler which have been deformed, broken, or otherwise damaged shall not be used. Care shall be taken in placing so that strips of the joint material

will butt tightly against the adjoining one.

(d) Rubber Filler for Joints. - A poured rubber joint filler conforming to the requirements of paragraph 9-15 shall be used in the construction joints of the bridge deck and in other joints above the preformed joint filler and elsewhere as indicated on the drawings or otherwise required by the contracting officer. The surfaces to be sealed shall be substantially dry and shall be thoroughly cleaned of all loose scale, dirt, and other foreign matter preparatory to pouring the joint filler. A block or form shall be used at each end to hold the material in the joint until it has set, and the filler shall be poured flush with the surface of the adjoining concrete or steel. Precautions shall be taken to prevent pouring any material on the exposed surfaces adjacent to the joint.

(e) Water Stops, Bituminous and Metal. - Metal water stops at the upstream face of the dam at vertical joints shall be backed up by six inch diameter wells filled with special bituminous filler, type "C", containing a steam heating unit, all as detailed and shown on the drawings.

The six-inch wells shall be formed by halved concrete pipe on one side of the well. The halved concrete pipe shall be non-reinforced, and of bell and spigot pattern, and shall conform to Federal Specification SS-P-371. The minimum thickness of shell shall be one inch and depth socket two inches. The halved or split faces shall be smooth and in one plane.

As the dam progresses in height, sections of the steam heating unit shall be installed in the wells, and the wells shall be filled solid with bituminous material. The special bituminous filler, type "C" shall conform to the requirements of paragraph 9-20. After completion of the dam, each vertical joint shall be heated by steam until the bituminous material is melted, and additional bituminous material shall then be introduced from the service gallery under pressure until no more can be added under pressures up to 100 pounds per square inch or as directed by the contracting officer. This filler will be supplied from the service gallery through a 4-inch wrought iron pipe. Inside this feeder pipe, and extending in continuous circuit from the bottom to the top of the six-inch well, shall be placed the 3/4-inch wrought iron steam pipe for use as a heater coil to soften the bituminous filler. The 4-inch wrought iron pipes shall extend beyond the surface of the concrete and shall be fitted with steel flanges as shown on the drawing. The wrought iron steam pipes and 3/4-inch nipple for supplying bituminous material shall extend 2 inches beyond the flange on the 4-inch pipe and shall be threaded and capped. All wrought iron pipe shall be genuine wrought iron conforming to the requirements of paragraph 9-22.

The metal water stops shall be of 16-gauge corrugated black iron 26-inches wide conforming to the requirements of paragraph 9-06, painted with bituminous paint, and bent as shown on the drawings. The ends of the strip shall be joined together and made watertight by welding which shall be subject to the approval of the contracting officer. The bottom of each water stop at monolith contraction joints shall be embedded 6 inches in firm rock and recess filled with mortar and mortar allowed to harden before placing first lift of the foundations. Immediately after removal of the form, the exposed metal water stops, concrete pipe and steam pipe shall be protected by boxes approved by the contracting officer.

Other water stops conforming to the requirements of the preceding paragraph shall be installed around galler openings at contraction joints and elsewhere as indicated on the drawings, or as otherwise required.

If supply conditions at the time of construction permit the use of copper seal strips, the contracting officer may direct that they be substituted for the corrugated iron strips. In such event the contractor shall furnish and install the copper strips and the contract price will be adjusted for any difference in cost in accordance with Article 3 of the contract. Copper strips, if used, shall conform to par. 9-11.

5-17. SAWDUST CONCRETE.

(a) Where concrete is indicated as a filler in the roofs of the buildings, it shall be mixed in the approximate proportion of 4 bags of cement to 7 cubic feet of sand and 7 cubic feet of sawdust, mixed as required by the contracting officer. The sawdust shall be saturated with water when it is introduced into the mixer. Test blocks of concrete shall be made by and at the expense of the contractor before the concrete is placed, to determine the correct proportions of the ingredients to obtain a sawdust concrete of proper qualities for nailing and permanently supporting the roof surfacing. The cement and sand shall conform to the requirements for regular concrete herein. The sawdust shall be cuttings of pine timber, coarse, clean and free from dust, shavings, and sticks, passing No. 4 sieve and retained on No. 16 sieve. The top surface of the concrete shall be given a smooth and even finish, and have a uniform slope to the gutters.

(b) If so elected by the contractor and approved by the contracting officer, a substitute for sawdust may be used. Any such substitute must be a commercial product of proven quality, prepared especially as a roof filler. When mixed and used as recommended by the manufacturer, the resulting product must have strength and nailing properties equivalent to that of sawdust concrete and its unit weight shall not be in excess of that of sawdust concrete of equivalent quality.

5-18. PRECAST POROUS CONCRETE DRAINS. - Precast porous concrete drains of the size and dimensions detailed shall be placed as indicated on the drawings. The porous concrete shall be mixed in the proportion of one part of Portland cement to five parts of aggregate by weight, the amount of water being such (a water-cement ratio of 0.33, plus or minus, by weight) that the resulting cement paste will not fill the voids in the aggregate but will thoroughly coat and bind the aggregate particles. The aggregate used shall all pass a screen having 3/4-inch square or equivalent round openings and shall all be retained on a screen having 3/16-inch square or equivalent round openings. The compressive strength of the porous concrete at seven days, as determined by tests of 6-inch by 12-inch cylinders made and tested in accordance with the latest standard specifications of the American Society for Testing Materials, shall be not less than 1000 lbs. per square inch. The porosity of the concrete at seven days shall be such that water will pass through a slab of the concrete 12 inches thick at the rate of not less than seven gallons per minute per square foot of slab, with a constant 4-inch depth of water on the slab. Cement and aggregates for porous concrete will be furnished by the Government. Payment for constructing and placing the precase porous concrete drains will be made at the contract unit price per lineal foot for "Drains; Porous Concrete."

5-19. MEASUREMENT AND PAYMENT.

(a) Concrete, General. - Measurement of concrete will be made on the basis of the actual volume of concrete within the neat lines of the

structures as indicated on the drawings or otherwise required. Measurement of concrete placed against the sides of the excavation without the use of intervening forms will be made only within the neat lines of the structure. No dedeuctions will be made for rounded or beveled edges or space occupied by metal work, electrical conduits, timber, nor for voids which are either less than five (5) cubic feet in volume or one (1) square foot in cross section. Unless otherwise specified, payment for concrete will be made at the respective contract prices per cubic yard for the various classes required, which prices shall include the use of all equipment, tools, material, false-work, forms and form lining, bracing, bolts, rods, metal ties, dowels, preformed expansion joint filler, rubber filler, built-up joint filler, canvas, mortar, labor, special provisions for hot and cold weather placing and curing, and all other items required to complete the concrete work.

(b) Additional Concrete. - Any other concrete to be placed and not specifically covered above will be paid for at that contract unit price for the concrete specified above which is most applicable to the additional concrete placed as determined by the contracting officer. The decision of the contracting officer regarding the classification of such additional concrete will be final. No payment will be made for any additional material whch may be authorized by the contracting officer at the request of and primarily for the benefit of the contractor, which is not found necessary and required and directed by the contracting officer under the provisions of these specifications.

(c) Measurement and Payment for Steel Reinforcement. - Steel reinforcement will be paid for at the contract unit price per pound for "Steel Erection; Concrete Reinforcing." The weights for payment shall be based on the amount actually placed in accordance with the dimensions and details on the bar schedules furnished by the Government or placed as directed by the contracting officer. Unit weights used in determining computed weights will be as follows:

Size of Bars, Inches	Weight, Pounds per Foot
3/8 round	0.376
1/2 round	0.668
1/2 square	0.850
5/8 round	1.043
3/4 round	1.502
7/8 round	2.044
1 round	2.670
1 square	3.400
1-1/8 square	4.303
1-1/4 square	5.313

(d) Measurement and Payment for Water Stops. - Payment for furnishing and installing the bituminous cement in the wells in the water stops will be made at the contract unit price per cubic foot for "Special Bituminous Filler, Type 'C;'" measured in place to the section indicated or required. Payment for funishing and installing corrugated iron water seals will be made at the contract unit price per pound for "Corrugated Iron Water Stops," and shall include all cost of painting, joining the ends, placing, protecting, and embedding in the foundations and sealing with grout. The payment for furnishing and placing the following items will be made at the contract unit price as follows: per pound for "Pipe; Wrought Iron," and per lineal foot for "Pipe; Concrete, Halved."

SECTION VI - BRIDGE AND ROADWAY

6-01. GENERAL. - The bridge spanning the spillway section of the dam will consist of 40 concrete encased steel girder spans, each approximately 60 feet in length center to center of supporting piers, with a clear gate opening of 50 feet. Each span will consist of three separate girders with a fourth girder supporting the upstream gantry rail. The bridge deck includes a 20-foot roadway, a standard gage railroad, and supports one rail of the gantry track, all as shown on the drawings. The upstream gantry rail is supported by a separate concrete encased girder and will be considered as part of the bridge and roadway of this section of the specifications. A service bridge of structural steel with grating floor will be supported under the roadway as shown on the drawings. Construction and expansion joints shall be as indicated on the drawings or as otherwise approved by the contracting officer. It is intended that the bridge deck spans over the first 14 spillway openings on the south end of the dam, except for concrete parapets, shall be erected as soon as pier monoliths 1 to 14 are ready to receive them, the crane rails placed and one traveling gantry crane erected and placed in operation, so that the crane may be used to operate the first 13 diversion gates. During the second stage of construction, the bridge deck and gantry rails over the next 7 openings shall be erected as soon as pier monoliths 15 to 21 are ready, in order to permit operation of the diversion gates in openings 16 to 20 inclusive.

6-02. STEEL GIRDER SPANS AND SERVICE BRIDGE. - The steel girder spans and service bridge shall be erected but not furnished by the contractor, see paragraph 1-10 and Section VIII.

6-03. CONCRETE. - The piers shall be of Class "B" concrete. The bridge floor, girder encasements and the parapet, including the pilasters above the bridge floor, shall be of Class "A" concrete. Forms for pilasters and parapets shall be provided with form lining as specified in paragraph 5-13 (e). Special care shall be taken in order that no horizontal joint is apparent at the junction of the bridge floor and parapet. Forms shall be cambered for dead load deflection, as directed by the contracting officer, to avoid any sag in horizontal concrete lines or surfaces.

6-04. CONCRETE FINISHING.

(a) Pavement.- After the concrete in the roadway has been brought to a true uniform grade it shall be struck off with a heavy template to the cross-section indicated on the drawings. The pavement shall receive a wood float finish as specified in paragraph 5-11 (a). Prior to final finishing operations, the surface shall be tested for trueness of surface and grade and any deviation exceeding one-eighth of an inch in ten feet shall be immediately corrected.

(b) Sidewalks. - The sidewalk shall receive a wood float finish as specified in paragraph 5-11 (a). The edge shall be finished by a steel edging tool to a smooth dense surface.

6-05. MISCELLANEOUS.

(a). Sidewalk and Roadway Drains. - The contractor shall furnish and install sidewalk and roadway drains complete as shown on the drawings. The drains shall be located and dimensioned as shown on the drawings, and the materials shall conform to the applicable requirements of Section IX.

(b) Handrailing. - (See paragraph 14-01).

(c) Gutters of 16-oz. copper shall be placed under the expansion joints in the spillway bridge deck as shown on the drawings.

(d) Paints and Painting. - (See Section X).

(e) Electric conduitspertaining to the power and lighting system shall be as specified in Section XIV or shown on the drawings.

(f) All pipes and/or conduits which cross expansion joints shall be fitted with suitable water tight sleeves, satisfactory to the contracting officer, to allow for expansion and contraction at the joint. The weight of the sleeves will be included in the weight for the pipe or conduit of which they form a part.

6-06. PAYMENT.

(a) Payment for the bridge concrete will be made at the respective contract unit price for the class required and will include the cost of finishing for the roadway and sidewalks.

(b) Erection of the steel girders for the bridge and gantry crane and the steel for the surface bridge under the roadway, including all embedded parts and fastenings pertaining thereto, will be paid for as provided in paragraph 8-06 (a).

(c) The payment for placing the gantry rails, and railroad rails including the bearing plates and anchorages as shown on the drawings, will be made as provided for in paragraph 8-06.

(d) The weight of cast iron sidewalk and roadway drains, furnished and installed, shall be included in the bid item "Iron; Cast," and payment will be made at the contract unit price per pound for that item.

(e) Payment for furnishing and placing copper gutters will be made at the contract unit price per pound for "Copper; Sheet".

SECTION VII

SPILLWAY GATES, GANTRY CRANES, FIXED HOISTS, AND APPURTENANCES

7-01. REQUIREMENTS.

(a) The work covered by this section comprises the unloading, storing, erecting, painting, insulating and testing of the spillway gates, fixed hoists, gantry cranes, and appurtenances. Appurtenances include structural steel guide towers, hoist towers, gate track and guide rails, sills, dogging equipment, lifting beams, crane collector bars and supports, and all castings, bearing plates, anchor bolts, machine bolts, field rivets, angle curbing, recess frames and other required fittings for the foregoing items. Placing of masonry plates, sills, and any other items requiring grouting in place shall include the grouting. Erection of the sills shall include pouring the babbitt sealing surface but payment for furnishing the babbitt will be made as noted in paragraph 7-12(c). All necessary fitting, welding and brazing for the foregoing items shall be included in the unit price for erection. Field painting shall be in accordance with Section X of these specifications. Field riveting, welding and brazing shall be in accordance with paragraph 14-15 of these specifications. Babbitt and other materials shall be as specified in Section IX. The work shall be complete as herein specified, but this section does not cover concrete work except for grouting incidental to erection of sills, masonry plates, anchor bolts and similar items.

(b) The material and equipment to be erected, except as noted below, including rivets and permanent connecting bolts, will be furnished by the Government. (See paragraph 1-10.) The contractor shall furnish the construction plant and all field paint, insulating compound, babbitt, solder, grease, welding rods, fitting-up bolts, tools, appliances, and any other items incidental to handling, storing, erection, painting and testing.

7-02. GENERAL DESCRIPTION.

(a) Embedded Parts. The embedded parts will consist of two structural steel guide towers in each spillway pier, anchor bolts and masonry plates for the towers, anchor bolts for the sills, and for the hoist towers, angle curbing at the gate slots and recess frames for dog-operating levers, and heater connection junction boxes.

(b) Gate Track and Guide Rails. The rails in the pier will consist of a 175# track rail and a 49.7# A.S.C.E. guide rail for each gate slot set vertically and fastened to the towers by cap nuts which are welded to the tower members, stainless steel studs and rail clips. Provision will be made for the lateral adjustment of the 175# rail and for adjustment of the 49.7# rail both laterally and in an up-and-downstream direction.

(c) Sills. The sills will consist of two structural steel rolled H-sections in each gate opening with slots formed on the top flanges by steel bars welded on. The purpose of these slots is to contain babbitt metal to form the horizontal gate-sealing surface. The sills will be placed in grout slots left in the concrete of the spillway and will be held in place by anchor bolts and by field welds to the guide towers at the ends. Joints will be located at the contraction joints in the spillway and copper water stops will be provided.

(d) Dogging Assemblies. The dogging assemblies will consist of

cast steel dogs in the piers operated by hand levers at the tops of the piers and vertical push rods running through pipe casings to the dogs. The dogs will be mounted on horizontal pins set in steel supports in the embedded towers.

(e) Spillway Gates.

(1) The spillway gates will be of the fixed-wheel type with the wheels cantilevered outside of the end posts. A total of 42 gates, including two spare gates, will be furnished, consisting of 24 single-section gates and 18 double-section gates with joints between sections at varying elevations. Eighteen of the single-section gates and the top sections of all of the double-section gates will be furnished equipped for temporary use for the river diversion (see paragraph 2-14). The 24 single-section gates and the top sections of 6 of the double-section gates will require field splicing. All other gate sections will be shipped complete, except for water seals and heaters, with wheels installed and aligned and with lifting mechanisms in place. Field splices will involve riveting the end connections of the horizontal girders to the end posts, stitch-riveting the double girder web at the splice, riveting the skin plate and down stream tie plate splices, installing and aligning wheels, connecting grease lines and filling with grease, calking or calk-welding all joints in contact with headwater, and installing the lifting and coupling mechanism in the six top sections requiring field splicing. The lifting and coupling mechanism is so designed that each double-section gate may be lifted as a unit, or each section lifted separately.

(2) At each end of each gate section will be a series of compartments inclosed by the skin plate on the upstream side, removable cover plates on the downstream side, the end post of the gate, and the inner vertical diaphragms which carry the ends of the wheel axles. The webs of the horizontal girders will form the top and bottom of each compartment. The purpose of these air spaces is to provide insulation between the water in the gate slots and the air on the downstream side of the gate. Electric heaters will be provided for installation in the bottom and top of each bottom section of the double-section gates. These heaters will run lengthwise of the gates and will be inclosed in an insulated sheet steel inclosure to reduce heat losses. Flexible water proof cables will connect the heaters with the power supply on the dam. Heaters and electrical connections will be installed by others.

(3) The water seals for all gates will be shipped separately to be installed by the contractor.

(f) Gantry Cranes. - Two gantry cranes operating on the same runway will be provided for operation of the spillway gates. Crane No. 1 will be equipped with cantilever extensions of the trolley tracks and housing to permit operation of the river diversion gates during construction and a gasoline driven auxiliary generator for operation of the crane in case of failure of the main power supply. Crane No. 2 will not have the cantilever extension or a gasoline driven generator auxiliary plant. Each crane will be equipped with a lifting beam furnished with the gates. The beams will be used for handling the permanent gates, and on crane No. 1, will be used for temporary operation of the river diversion gates. On each crane, gates will be handled by two fixed main hoists on a single trolley which will move up and downstream. The main hoist for crane No. 1 will be of 260-ton capacity and that for crane No. 2 of 175-ton capacity. A 10-ton auxiliary hoist will be provided on the trolley of each crane. The crane collector bars will be located in a steel inclosed slot in the concrete encasement on the upstream side of the upstream crane girder over the spillway, and in the upstream face of the north bulkhead section.

(g) Hoists. - Each double-section gate opening (designated Nos. 21 to 38 inclusive on the drawings) will be equipped with fixed hoists for independent operation of the gates. The 175-ton capacity hoists will be similar to those on the crane trolleys and will be mounted on structural steel towers with bases on the pier tops. The hoists will be made so that they may be removed from the towers by either of the gantry cranes in order to permit removal of the gates from the slots.

7-03. DRAWINGS. - The general arrangement of the material and equipment to be erected is as shown on the drawings. Complete erection drawings will be furnished by the contractor by the contracting officer.

7-04. UNLOADING AND HANDLING. - All material and equipment shall be carefully handled during unloading and placing in final position so that no parts will be bent, broken or otherwise damaged. Hammering or wedging that will distort or injure the members will not be permitted, and members shall not be overstressed during the process of unloading, handling and erection. The contractor shall unload all material promptly upon arrival at the site, otherwise he shall be responsible for demurrage charges and/or damages. (See paragraph 1-10.) He shall check all material turned over to him against shipping lists and report any shortage or damage discovered promptly in writing to the contracting officer. If the sequence of operations requires it he shall store all material under cover and protect it from the elements until it is placed in final position.

7-05. EMBEDDED PARTS. - All parts embedded in concrete shall be clean and free from coating, rust, paint, scale, oil or any foreign matter. All anchor bolts and masonry plates shall be accurately set and grouted in place to lines and grades shown on the drawings. The gate guide towers shall be accurately plumbed and aligned and held rigidly in position during depositing of the concrete. Curb angles and recess frames shall be field-welded at the points indicated on the drawings and held to true position while the concrete is being deposited. Watertight connections shall be made between the bottoms of the heater casings in the towers and the drains in the piers below by means of the couplings furnished with the drains.

7-06. GATE TRACK AND GUIDE RAILS. - After the pier concreting has been completed the 175# track rail on the downstream side of each gate slot shall be adjusted to a plumb position and to correct center-to-center distance from the rail in the opposite slot in the adjacent pier by means of the adjusting studs through the rail web. The rail clips shall then be drawn tight in proper position against the rail flanges by means of the rail clip studs, providing a secure and rigid fastening to the guide tower members. The 49.7# guide rail on the upstream side of each gate slot shall then be adjusted to a plumb position and to the proper distance from and in line with the downstream rail in the same slot by means of the shims and adjusting studs provided. The fastenings shall be drawn tight to secure a firm and rigid connection to the guide tower member. The rails will be match-marked in the shop before shipping, and care shall be taken that splices are made with the proper pieces and that the contours of the heads are flush at the joints.

7-07. SILLS.

(a) The gate sills shall be set by means of the anchor bolts and adjusting nuts to proper line and grade in the grout slots provided. The copper water stops shall be fitted neatly to the sill beams at the joints and

brazed, the brazed connection to the water stop in the spillway made, and the ends of the sills welded to the guide towers. The whole sill assembly shall be held rigidly in place while the grout is being poured. Grout shall be poured to the top of the bars welded to the top flange of the sill beams and to a smooth contour with the spillway curve. Care shall be taken that grout is kept out of the recess to contain the babbitt metal.

(b) After the grout has thoroughly set, the slot in the top of the sill shall be filled with the babbitt metal specified and to a height of 1/4" above the bars. The temperature of the babbitt while pouring shall be approximately 915° F. After the babbitt is poured it shall be hammered thoroughly so as to completely fill the slot, and shall be smoothed off flush with the tops of the steel bars forming the slot. It is important that the surface of the babbitt along its entire length lie in a true plane to match the bearing surface on the bottom of the gate.

7-08. DOGS AND OPERATING DEVICES. - After the piers are completed the dogs shall be installed in the dog-supporting members in the piers and the pins driven. The operating rods, levers and grease piping shall then be installed. The operating rods shall be adjusted so as to permit free movement of the dog between extreme positions shown on the drawings.

7-09. GATES. - The gate sections requiring field splicing will be completely assembled in the shop, holes for field rivets reamed and the sections match-marked before shipping. Care shall be taken to splice the proper sections. Splices shall be riveted except for points requiring welding for watertightness. Joints may be calked or calk-welded as authorized by the contracting officer. After the structural parts of the gate sections are spliced, the wheel assemblies shall be installed and the wheels adjusted to a true line by means of the eccentric provided in the axle. The wheels shall be held securely in this position by bars welded on either side of the flattened part of each axle to the inner vertical diaphragm of the gates. The bronze retaining nuts shall then be drawn tight. Grease piping shall then be installed and secured in place, the flexible connections made to the fittings on the wheel axles and the wheel bearings filled with grease. Each completely spliced section shall form a truly plane surface on the skin plate side, the end posts shall be parallel and at right angles to the horizontal girders, and the side sealing surfaces shall be vertical and in correct alignment. After all sections are spliced, the lifting and coupling devices shall be placed in the spliced top sections and connections made between the lifting bars and the sliding cross-heads. Under no circumstances shall the double-section gates be laid flat or tilted materially out of a vertical plane while the sections are coupled together. Particular care shall be given to aligning the gate wheels. After final assembly, lines through the center of the wheel treads at each end of any gate shall be in the same plane and parallel. Side seals for all gate sections shall be carefully adjusted to provide the proper amount of play in the holding bolts. The rubber seals on the top sections shall be fitted in place to form watertight joints. When the gates are ready for installation, the inside surfaces of each compartment at the ends described in paragraph 7-02(e) (2), except the intermediate horizontal girder webs but including the cover plates, shall be coated with an instulation compound conforming to the requirements of paragraph 9-18. The minimum thickness of the coating after drying shall be 1/2 inch. The preparation, if required, of the surfaces to be coated shall be such as to cause the insulating compound to adhere firmly to the steel. Care shall be taken to avoid coating the wheel axles, grease pipes and fittings.

7-10. CRANES, HOISTS, LIFTING BEAMS, AND COLLECTOR BARS.

(a) The gantry cranes with lifting beams shall be installed on the gantry runway and the collector bars shall be placed in the proper position in the slots provided. Anchor bolts and bases for the fixed hoist towers shall be accurately set to line and grade and the towers properly aligned. The hoists shall be assembled as units, set on the towers, fastened in place, and electrical connection made. Crane No. 1 shall be erected first, and tests as specified below completed before the scheduled time for operation of the river diversion gates. The contractor shall adhere to the best modern practice and workmanship in erection and testing of cranes, hoist towers, hoists, lifting beams, and collector bars and shall place all of his men working on the erection and testing under the supervision and direction of the erection engineer furnished by the crane and hoist manufacturer. The services of the erection engineer will be paid for by the crane and hoist manufacturer.

(b) The contractor will be permitted to use either or both gantrys and equipment in doing any work under this contract for which they are suitable, on condition that he shall provide competent operators and proper care for the cranes until the completion of the contract. He shall also provide any necessary temporary electric service lines and power for crane operation. Before the final contract payment is made, the contractor shall, if required by the contracting officer, repaint the cranes and make good to the satisfaction of the contracting officer any damage to them that may have resulted from the contractor's use thereof.

7-11. TESTING.

(a) After installation of the gate dogging devices, the parts requiring lubrication shall be greased with an approved lubricant and the whole assembly tested for satisfactory operation. The coupling devices in the double-section gates shall be greased and tested for satisfactory operation, the centralized wheel greasing systems in all gates checked and wheel bearings filled with grease, using the portable grease pump furnished with the gates.

(b) After separate testing of the coupling and dogging devices, the gates shall be lowered into the slots and each gate tested by raising and lowering it several times throughout its full range, using the crane for crane-operated gates and the individual hoists where these are installed. The dogging devices shall be tested by the operation of dogging each gate. Tests shall be repeated and necessary adjustments made in the gates, dogging assembly and guides until the operation of all equipment is satisfactory to the contracting officer.

(c) Field tests of the completed cranes, fixed hoists, and lifting beams shall be performed by the contractor as directed by the contracting officer. Tests shall include the normal functions for which the cranes, hoists, and lifting beams are designed. Crane No. 2 shall raise, lower, transport on the runway at the specified speeds, and hold in any position a test load 25% in excess of its rated capacity. Crane No. 1 shall raise, lower, and hold in any position a test load equal to the rated capacity of the main hoist, with the trolley in its extreme upstream position on the cantilever arm and the gantry centered over a gate opening. With the trolley in extreme upstream position, Crane No. 1 shall transport on the runway a test load of 225 tons. In addition, Crane No. 1 shall, with the trolley in any position between the gantry rails, transport on the runway at the specified speed a test load equal to that specified for Crane No. 2. The fixed hoists shall raise and lower at the specified speed and hold in any position a test

load 25% in excess of their rated capacity.

7-12. MEASUREMENT AND PAYMENT:

(a) The quantity to be paid for in erecting and placing in final position spillway gates, guide towers, guide rails, sills, dogging equipment, curbing, recess frames, and incidental items, shall be on the basis of weight determined as specified in paragraph 9-39. Payment will be made at the contract unit price per pound for "Spillway Gates; Erection," which payment shall cover all necessary material and work for erection, as indicated on the drawings or as called for in these specifications. Placing of any material or equipment covered in this section in temporary position for use during river diversion will be paid for as specified under Section II, 'Diversion and Care of the River."

(b) Payment for the erection of the cranes, hoists, lifting beams, collector bars, and incidental items will be made at the contract lump sum price for "Gantry Cranes and Fixed Hoists; Erection."

(c) Payment for furnishing and placing babbitt will be made at the contract unit price per pound for "Babbitt," computed on the basis of 0.270 pounds per cubic inch.

(d) All cement for grout will be furnished by the Government. The grout shall be the same cement-sand ratio as the adjacent concrete and as approved by the contracting officer.

SECTION VIII - STRUCTURAL STEEL AND TRACKS

8-01. REQUIREMENTS.

(a) The work covered by this section comprises the unloading, storing, erecting, and painting of the steel girders for the spillway bridge, the service bridge under the spillway bridge, the inclosure for the crane collector bars, the gantry and railroad rails on the spillway and bulkhead sections of the dam, the steel for the elevator shaft not customarily installed by the elevator shaft not customarily installed by the elevator manufacturer, the nose armor for the spillway piers, and the steel in the machinery, electrical, and repair bays, in the gate storage slots, including guide rails, and all other miscellaneous structural steel shown on the drawings excepting items for which payment is otherwise provided. All necessary fitting, field riveting, welding, brazing and placing of all castings, bearing plates, sole plates, bolsters, shoes, anchor bolts, turned bolts and other required fittings for the foregoing items shall be included in the work. Placing of any items requiring grouting in place shall include the grouting. Erection of structural steel to be embedded in concrete shall include removal of shop paint and cleaning in accordance with paragraph 8-05 (a). Field painting shall be in accordance with Section X of these specifications. Field riveting, welding and brazing shall be in accordance with paragraph 14-15 of these specifications. The work shall be complete as herein specified, but this section does not cover concrete work except for grouting incidental to placing of anchor bolts, masonry plates, end bearing details and similar items.

(b) The material and equipment to be erected, except as noted below, including rivets and permanent connecting bolts, will be furnished and delivered at the transfer yard by the Government. The contractor shall furnish the construction plant and all field paint, welding rods, fitting-up bolts, tools, appliances, and any other items incidental to handling, storing, erecting, and painting.

(c) With the approval of the contracting officer, the contractor will be permitted to use the steel bridge girders temporarily during construction for any purpose for which they are suitable. They shall be properly maintained, shall not be overstressed, and shall be resotred to their original condition after their temporary use. In case of irreparable damage to any girder, it shall be replaced at the contractor's expense.

8-02. GENERAL DESCRIPTION.

(a) The spillway bridge will extend from the south bulkhead over the spillway to the north bulkhead. Steel girders encased in concrete will carry the gantry and railroad tracks and the highway over the spillway. It is expected that each girder will be furnished and shipped in one piece so that no field splicing will be necessary. The estimated weight of each gantry girder complete is approximately 52,000 pounds, and each highway and railroad girder is approximately 36,000 pounds. The railroad and highway will be carried over the repair, machinery, and electrical bays in the north bulkhead section of reinforced concrete construction. The gantry rails will be carried by the upstream and downstream walls on the north bulkhead section.

(b) The service bridge will be under the upstream side of the roadway and will extend the full length of the spillway. It will consist of open steel grating floor supported by rolled sections as shown on the drawings.

(c) The inclosure for the crane collector bars consists of steel plates and angles anchored to the concrete encasement on the upstream side of

the upstream crane girder over the spillway and to the upstream face of the dam on the north bulkhead section.

(d) The gantry and railroad rails will rest on bearing plates which will be set in grout slots left in the concrete and adjusted to grade by means of shims underneath. The rails will be held in place by anchor bolts and rail clips at the bearing plates and lateral adjustment will be provided by clearance in the clips. After final adjustment of the rails the slots shall be filled with grout and Class "A" concrete as shown on the drawings. All rails will be curved to suit the curvature of the dam axis as shown on the drawings.

(e) The steel for the elevator hoist supports will be located at the top of the pier house at the north end of the dam and will consist of rolled sections with bearing plates and fittings carried by the concrete of the pier house.

(f) The steel in the repair, machinery, and electrical bays will include supports for machinery and electrical equipment, runways for hoists, steel for hatches and hatch coamings and supports for gates while they are being repaired.

(g) The steel in the gate storage slots will comprise structural bases to support the gates and guide rails with bearing plates and anchors which shall be set as shown on the drawings.

(h) The nose armor for each pier will be a structural steel angle section held in place by strap anchors embedded in the concrete.

(i) Ladders will be required on the spillway piers, in the pier houses, in the pump sumps, and at other places as shown on the drawings. Circular guards will be required on the ladders where indicated.

8-03. DRAWINGS. - The general arrangement of the material and equipment to be erected is as shown on the drawings (See paragraph 1-04). Complete erection drawings will be furnished the contractor by the contracting officer.

8-04. UNLOADING AND HANDLING. - All material and equipment shall be carefully handled during unloading and placing in final position so that no parts will be bent, broken or otherwise damaged, (See paragraph 1-10). Hammering or wedging that will distort or injure the members will not be permitted, and members shall not be overstressed during the process of unloading, handling and erecting. Steel beams and girders shall not be laid flat. The contractor shall check all material turned over to him against shipping lists and report any shortage or damage discovered promptly in writing to the contracting officer.

8-05. ERECTION.

(a) All anchor bolts, bearing plates, bolsters, shoes, bearing castings, and similar items for supporting or holding in place the structural steel members shall be carefully set to proper line and grade as established by the contracting officer, and maintained in this position. Bearing plates and castings shall be leveled by means of steel wedges or by shims or adjusting nuts if called for on the plans. Grout for setting them shall be of an approved mix and shall be so placed as to secure a full and uniform bearing. All structural steel surfaces to be embedded in concrete shall be thoroughly cleaned, free of grease, rust, mill scale, loose particles, dirt and other foreign material. Methods of cleaning shall be approved by the

contracting officer. Shop paint shall be removed by sandblasting or other approved methods not more than 5 days prior to pouring the encasing concrete.

(b) The spillway bridge girders shall be carefully set on the end bearings, bolted in place and held to true alignment during placing of reinforcement and forms for the encasement and pouring of the concrete. Particular care shall be given to proper arrangement of the expansion end details. Loads on the unbraced girders during construction shall be kept as nearly as possible symmetrical about the longitudinal axis.

(c) The enclosure for the crane collector bars shall be held firmly in the forms to correct grade and alignment until the concrete encasement has set.

(d) The rails for the gantry and railroad tracks shall be set on the base plates and anchored after the plates are leveled and adjusted to proper grade and alignment. Care shall be taken that rails of the proper curvature are used, that the gage is accurately maintained, that the rails are truly level and at the correct elevations and that they are securely anchored in place. All splice bars and any other fittings shall be securely attached and the slots filled with grout and concrete of approved mix. Where shown on the drawings the surface of the concrete shall be recessed to provide wheel flange clearance.

(e) Steel members for the elevator hoist support shall be accurately set with respect to the shaft and held in this position until any concreting or grouting required is completed. Steel members in the machinery, repair, and electrical bays shall be accurately set in proper position as shown on the plans. Bases for support of the gates in the storage slots shall be level and shall support the gate in a plumb position. The guide rails shall be accurately plumbed so that the rail heads at opposite ends of the opening are in the same vertical plane and the proper distance between rail heads is maintained.

(f) The service bridge, ladders, and other structural steel parts shall be erected as shown on the drawings. They shall be accurately fitted and lined up and securely anchored to the concrete.

8-06. MEASUREMENT AND PAYMENT.

(a) The quantity to be paid for in erection of structural steel in final position shall be on the basis of weight determined as specified in paragraph 9-39. Payment will be made at the contract unit price per pound for "Steel Erection: Structural," which payment shall cover all necessary material and work for erecting, fabricating, painting, and placing as indicated on the drawings or as called for in these specifications.

(b) The quantity to be paid for in placing the gantry and railroad rails including all fittings and anchorages as shown on the drawings shall be on the basis of weight determined as specified in paragraph 9-39. Payment will be made at the contract unit price per pound in place for "Steel Rails, Placing."

(c) All cement and sand for grout will be furnished by the Government. The grout shall be the same cement-sand ratio as the adjacent concrete.

SECTION IX

METALS AND MISCELLANEOUS MATERIALS

9-01. GENERAL

(a) Materials. - All materials shall be of new unused stock, free from defects. Substitution of size of sections and materials from that shown on the drawings or required in the specifications shall not be made except on written approval of the contracting officer and provided that the cost to the Government shall not be increased thereby.

Materials indicated on the drawings or required in the work and not covered elsewhere in these specifications by detailed requirements, shall conform to the requirements of this section.

Any materials required which are not covered by detailed specifications herein or elsewhere in the specifications shall conform to the applicable Federal Specifications, grade and/or class as required or, in case where there are no applicable Federal Specifications, to applicable specifications of the American Society for Testing Materials (A.S.T.M.). In all other cases not specifically covered in these specifications the contractor shall furnish the highest grade commercial material or product.

(b) Inspection, Acceptance and Rejection of Materials. - All materials shall be subject at all times to inspection by the contracting officer who will select such samples in such quantities as he may deem necessary and subject the same to such tests as may be necessary to determine their qualities as herein specified, and he will accept or reject materials in accordance with the results of such tests. Tests may be repeated upon arrival of the various shipments at the site of the work to insure the acceptance of only such materials as will comply with the provisions of the plans and specifications.

(c) Test Specimens. - Special test specimens shall be furnished by the contractor on request; and shall be of such shape and number as designated; and shall in general conform to Federal Specifications or the specifications of the Americas Society for Testing Materials as to shape, size, and method of testing.

(d) Mill test reports. - Mill test reports certified to by qualified technicians shall be furnished when required for all material entering into this work and will, in general, be the basis of acceptance or rejection of the materials. The contracting officer may, however, require of the contractor special chemical or physical test on any part of the material if in his opinion the conditions justify such a check.

9-02. FEDERAL SPECIFICATIONS. - Copies of Federal Specifications referred to herein may be procured from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a price of five or ten cents each. When the term: "Federal Specifications" or "A.S.T.M. Specifications" is cited, the reference shall be construed to mean the specifications as modified by any amendments promulgated before the date of opening bids for the contract. The number and designation of the Federal Specifications of A.S.T.M. Specifications for various materials to be furnished under this contract are as hereinafter enumerated.

9-03. CAST IRON SAFETY TREAD. - Cast iron safety tread shall conform in all respects to Federal Specification RR-T-661, for "Treads; Safety, Metallic", Type "B" and Class "6". Safety tread shall have a minimum thickness of 5/16 inch, and shall be of the lengths and widths shown on the drawings. Safety

tread shall have a diamond pattern and shall have a nosing of not less than ¼ inch. Treads shall be set flush with the surface and shall be firmly anchored.

9-04. STRUCTURAL STEEL. - Unless otherwise specified, all steel for general purposes shall conform to Federal Specification QQ-S-711a for "Steel, Structural; (for) Bridges," Class "A", except that the Chemical properties shall be so controlled as to permit it to be easily welded by the arc-welding process.

9-05. CONCRETE REINFORCING STEEL. - Reinforcing steel will conform to Federal Specification QQ-B-71a, for "Bars; Reinforcement," (for) Concrete, Type "B" (Deformed). Bars will be Grade 2 (Intermediate Billet Steel), or Grade 3 (Intermediate Car Axle Steel). The steel will be properly identified as to grade.

9-06. SHEET METAL. - Sheet metal shall conform to Federal Specification QQ-I-696 for "Iron and Steel; Sheet, Black and Zinc Coated (Galvanized)" of the type and class as specified or required. When so specified, sheets shall also conform to definite chemical requirements.

9-07. BOLT STEEL. - Bolt steel shall conform to Federal Specification FF-B-571a and Amendment No. 1 dated April 1935 for "Bolts; Nuts; Studs; and Tap Rivets (and Material for Same)," Class "B" steel, unless otherwise specified or required.

9-08. STEEL FLOOR GRATING AND FASTENERS. - Steel floor grating and fasteners shall conform in all respects to Federal Specification RR-G-661a for "Gratings, Steel, Floor (Except for Naval Vessels)," and shall be made of the material and class as specified or required.

9-09. IRON CASTINGS.

(a) Cast Iron. - Cast iron, unless otherwise specified, shall conform to Federal Specification QQ-I-652 for "Iron, Gray; Castings," of class as required.

(b) Cast Malleable Iron. - Cast Malleable Iron shall conform to Federal Specification QQ-I-666 and Amendment 1, dated November 1934, for "Iron, Malleable; Castings," Black (Ungalvanized) Type "A," and Zinc Coated (Galvanized) Type "B."

9-10. BRONZE CASTINGS. - Bronze castings shall conform to Federal Specification QQ-B-691a for "Bronze; Castings," Type I, "Composition 4," unless otherwise specified or required. Castings for valves and fittings shall be Type I, "Composition 2 ".

9-11. COPPER.

(a) Plate and Sheets. - Copper plate and sheets shall conform to Federal Specification QQ-C-501 and Amendment 1 dated November 1936 for "Copper; Bars, Plates, Rods, Shapes, Sheets, and Strips."

(b) Piping. - Copper piping shall conform in all respects to Federal Specification WW-T-799 and Errata - 2, dated April, 1934, for "Tubing; Copper, Seamless (For Use with Soldered or Flared-Fittings)," Type "K" or "L" as specified or required. Fittings for copper piping shall be die cast brass or copper fittings with capillary channel and feed holes for solder for sweating in place and shall bear the name of the manufacturer stamped thereon.

9-12. BRASS.

(a) Sheets and Rolled or Drawn Shapes. - Sheets and rolled or drawn shapes shall conform to Federal Specification QQ-B-611a for "Brass, Commercial; Bars, Plates, Rods, Shapes, Sheets and Strips," Composition "C" of type and temmer as specified or required. Metal for screws and bolts shall be composition "D," half hard.

(b) Castings. - Castings shall conform to Federal Specification QQ-B-621 and Errata 1 dated February 1934 for "Brass, Commercial and Naval; Castings," Composition "B" (Commercial brass castings).

(c) Pipe. - Pipe shall conform to Federal Specification WW-P-351 and Errata 1 dated October 1930 for "Pipe; Brass, Seamless, Iron-Pipe-size, Standard and Extra-Strong," Grade "A".

(d) Pipe Fittings. - Pipe fittings shall conform to Federal Specification WW-P-448 for "Pipe-Fittings; Brass or Bronze (Threaded), 125-pound," or to Federal Specification WW-P-461 for "Pipe-Fittings; Bronze (Threaded), 250 pound," as specified or required.

9-13. SOLDER.

(a) Solder shall conform to Federal Specification QQ-S-571 for "Solder; Tin-Lead," Grade "A" or "C" as specified or otherwise required.

(b) Solder for Brazing shall conform to Federal Specification QQ-S-551 for "Solder; Brazing," of composition as specified or otherwise directed.

9-14. BABBITT METAL. - Babbitt metal shall conform to Federal Specification QQ-M-161 for "Metal, Antifriction; Castings and Ingots," Grade 3, unless otherwise specified or required.

9-15. RUBBER FILLER FOR CONCRETE EXPANSION JOINTS. - Compound shall be a thermoplastic rubbery, resilient, adhesive material, suitable for being readily poured into the joint at a temperature of 400-450 degrees F., and of a quick-setting type. The material shall remain homogeneous after prolonged heating at temperatures not lower than 450 degrees F. with no material change in character or viscosity. When poured, it shall solidify within 1 hour, shall adhere tightly to concrete, steel and bituminous surfaces, shall remain adhesive and resilient after prolonged exposure to freezing temperatures and to weathering, and shall be unaffected by dilute or concentrated solutions of calcium chloride. It shall have a softening point (Ring and Ball A.A.S.H.O. T-53) of not less than 80 degress C. nor more than 95 degrees C. The material shall be similar and equal to "Thermoplastic" as obtainable from Dispersion Processes, Inc., Naugatuck, Connecticut, or "Rai-seal" as manufactured by Rubber Associates, Inc., New York City, or "Sealz" as manufactured by Solvents and Plastics Co., Louisville, Ky.

9-16. LIME. - Lime shall conform in all respects to Federal Specification SS-L-351, for "Lime; Hydrated (for) Structural Purposes", Type "M" of "F" as specified or required.

9-17. PUTTY. - Putty for glazing shall comform in all respects to Federal Specification TT-P-791a, "Putty; Pure-Linseed-Oil, (For) Wood Sash-Glazing", or TT-P-781 "Putty and Elastic Compound; for Metal Sash-Glazing".

9-18. PLASTIC CORK.

(a) General. - Plastic cork filler or insualtion shall consist of granulated cork, asbestos fiber, and bituminous binder, thoroughly mixed, and thinned with high volatile naphtha to a suitable consistency for application to concrete, metal, wood and expanded metal lath, and shall have an adhesive value not less than its internal strength of cohesion when thoroughly set and dry.

(b) As taken from the container, the material shall be homogeneous and show no separation of ingredients that cannot be readily overcome by stirring. The cork content shall be not less than 67 percent by volume and the whole shall pass a No. 6 mesh sieve. The volatile material shall not exceed 55 percent by weight. Not more than 30 percent by weight shall be insoluble in carbon bisulphide, and such insolubles shall be wholly cork and asbestos fiber. After evaporation of the solvent, the soluble matter shall have a softening point at not lower than 165 degrees F., and shall show a penetration of from 8 to 20 at 77 degrees F. when tested in accordance with A.S.T.M. Specification D-5-25 for "Penetration of Bituminous Materials".

9-19. PREFORMED JOINT FILLER. Preformed joint filler shall be cork conforming to Federal Specification HH-F-341 for "Filler, Expansion-Joint, Preformed; Non-Extruding and Resilient-Types (for Concrete)." Type II self-expanding cork, 1 inch thick.

9-20. SPECIAL BITUMINOUS CEMENT.

(a) Type B. - Type B shall be an internal set-up cement of asphaltic base, composed of a liquid asphaltic fluxing agent with an admixture of powdered asphalt, asbestos fibre and other suitable inorganic fillers. When mixed in the proper proportions, the cement shall be suitable for proper trowel application, and shall harden to a consistency as specified in subparagraph (3) below;

(1) The material shall be supplied in containers of proper relative size to apportion batches with the desired troweling consistency. The liquid asphaltic fluxing agent shall be a smooth uniform mixture, not thickened or livered, and showing no separation which cannot be easily overcome by stirring. The powdered cement shall be a uniform mix containing no matted lumps of fibre.

(2) When mixed in the proportions recommended by the manufacturer, the cement shall yield no less than 85 percent of non-volatile matter when 10 grams are heated in an oven at 105 to 110 degrees Centigrade for 24 hours.

(3) When tested in accordance with A.S.T.M. Specification D-5-25 for "Penetration of Bituminous Materials", the above mixture shall have the following characteristics:

Immediately after mixing, using a 5/8-inch diameter steel ball, 114 grams, 5 seconds, the mixture shall permit a penetration greater than 300. The same specimen, after a lapse of 24 hours at 25 degrees C. under water, shall permit a needle penetration, 100 grams, 5 seconds, of not more than 100. The same specimen after a lapse of 30 days at 25 degrees C. under water shall permit a needle penetration, 100 grams, 5 seconds, of not more than 50.

(b) Type "C". - Type "C" cement shall be an internal set-up cement as specified for Type "B" except that it shall have a melting point of between 50 and 55 degrees C., and shall have a needle penetration at 25 degrees C., of not less than 80.

9-21. STEEL PIPE AND FITTINGS.

(a) Welded or Seamless Steel Pipe, Black or Galvanized, class and coating specified or required, shall be of standard commercial grade and sizes in conformity with Federal Specification WW-P-403a for "Pipe; Steel and Ferrous Alloy, Wrought, Iron-Pipe Size", except that test will not be required. Open ends shall be reamed. The pipe shall be straight, clean, and free from scale, rust, oil or other foreign matter.

(b) Fittings. Screwed fittings shall be of standard weight, malleable iron, conforming to Federal Specification WW-P-521a for "Pipe-Fittings; Malleable-Iron (Threaded), 150 Pounds", black or galvanized as required, plain screw type. All fittings shall be of the same weight or grade as the pipe with which they are used.

9-22. WROUGHT IRON PIPE AND FITTINGS. - Wrought iron pipe and fittings shall conform to Federal Specification WW-P-441a for "Pipe; Wrought-Iron, Welded, Black and Zinc-Coated", of the class and sizes as indicated or required. Open ends shall be reamed. The requirements in the specifications for fittings for steel pipe shall apply also to fittings for wrought iron pipe.

9-23. CAST IRON PIPE AND FITTINGS.

(a) Pipe. - Unless otherwise indicated on the drawings or directed by the contracting officer, cast iron pipe shall conform to the specifications of the American Standards Association for Pit Cast Pipe for the class required. The pipe shall be furnished with the standard coal-tar-dip coating. Ends shall be either plain, bell and spigot, or American Standard Flanged, as required. Cast iron soil pipe shall conform to Federal Specification WW-P-401 for "Pipe and Pipe Fittings; Soil, Cast Iron." Threaded cast iron pipe shall conform to Federal specification WW-P-356 for "Pipe, Cast Iron; Drainage, Vent, and Waste (Threaded)."

(b) Threaded Fittings shall conform to Federal Specification WW-P-501a for "Pipe-Fittings; Cast-Iron (Threaded)" of type and class as shown or required.

(c) Flanged Fittings shall conform to American Standards, class as indicated or required.

9-24. EMBEDDED HANGER SUPPORTS.

(a) Embedded Inserts for pipe supports shall be for threaded rods similar and equal to the adjustable loop type manufactured by the Grinnel Company, of the sizes required.

(b) Expansion Shields and Sleeves for Pipe Supports shall be for threaded rods of the sizes shown on the drawings, and of the type approved by the contracting officer.

9-25. STANDARD BOLTS, SCREWS, AND PINS.

(a) Bolts, Nuts and Studs shall conform to Federal Specification FF-B-571a and Amendment 1, dated April 1935, for "Bolts; Nuts; Studs; and Tap-Rivets, (and material for same)". Unless otherwise specified or required, bolts shall be of Type "B-2" and nuts of Class "C" steel, type "A-2", with Class 3 medium fit. Zinc or cadmium coated bolts shall be furnished where specified, indicated or required.

(b) Machine and Set Screws shall conform to Federal Specification FF-S-91 for "Screws, Machine; (including Screws, Set)" Class 3 medium fit, unless otherwise specified. Machine screws shall be of the type and material required. Set screws less than 3/8-inch in diameter shall be Type "D", and those 3/8-inch in diameter and over shall be of Type "G" unless otherwise specified or required.

(c) Split Cotter Pins shall conform to Federal Specification FF-P-386 for "Pins; Cotter, Split" of the type as required.

9-26. LOCK WASHERS. - Lock washers shall be of the "Kantlink" type and shall conform to the S.A.E. standard dimensions and requirements, for lock washers of regular section. Material shall be either S.A.E. X1055 or S.A.E. 1060.

9-27. STEEL WIRE ROPE. - Steel wire rope shall conform to Federal Specifications RR-R-571 and Amendment 4, dated January 1941, for "Rope; Wire" of sizes and types as specified or otherwise required.

9-28. CHAINS AND ATTACHMENTS. - Chains and attachments shall conform to Federal Specification RR-C-271 and Amendment 2 dated November 1934, for "Chain and Atta chments; Standard, Miscellaneous". Chains shall be Type "A", Grade "II", and as otherwise specified.

9-29. FLOOR PLATING. - Floor plating indicated on the drawings shall be of carbon steel of the thickness specified or required, with a raised pattern on one side which will provide a non-skid surface in any direction. The reverse side of the plates shall be smooth. The specified thickness of the plate shall be exclusive of the raised pattern, which shall project not less than 5/64-inch and shall have a top free from sharp corners. They shall be closely spaced so that the foot will always be in contact with several of the raised portions.

9-30. BUILDERS' HARDWARE.

(a) Builders' Hardware shall conform to the following Federal Specifications unless otherwise specified.

FF-H-106 and Amendment 1 dated November 1934 for "Hardware, Builders'; Locks and Lock-Trim,"
FF-H-116a for "Hardware, Builders'; Hinges."

(b) Locks shall be of the pin-tumbler type with not less than 5 tumblers, and shall be of weather and moisture proof construction (see paragraph 11-06 (c)). Padlocks shall conform to Federal Specification FF-P-101a and Amendment 3 dated July 1939 for "Padlocks," Type 1a, size 1-3/4 inches. All padlocks shall be legibly stamped, 'C. of E., U.S.A."

9-31. PRESSURE LUBRICANTS. - Grease for pressure lubrication, except that for spillway gate wheel bearings, shall conform to Federal Specification VV-G-681 for "Grease; Lubricating, Mineral," "Medium" grade; pressure lubricant for spillway gate wheel bearings shall be that recommended by the bearing manufacturer and shall be effective at minus 40 degrees F.

9-32. ASPHALT - SATURATED FELT. - Asphalt-saturated felt shall conform to the requirements of Federal Specification HH-F-191, "Felt; Asphalt-Saturated, (for) Flashings, Roofing and Waterproofing."

9-33. PITCH. - Pitch shall conform in all respects to Federal Specification R-P-381, for "Pitch; Coal-Tar (for) Mineral-Surfaced Built-up Roofing, Water-Proofing and Damp Proofing," Type "I".

9-34. CONDUIT. - Rigid steel conduit, enameled, shall conform to Federal Specification WW-C-571 dated June 6, 1933, for "Conduit; Steel, Rigid, Enameled."

9-35. BITUMINOUS MACADAM ROAD SURFACING.

(a) Bottom Course. - The bottom course bituminous macadam materials shall conform to the specifications of the State of New York, Division of Highways, Item 45-- S - Bottom Course Bituminous Macadam - Penetration Method.

(b) Top Course. - The top course bituminous macadam materials shall conform to the specifications of the State of New York, Division of Highways, Item 53 - Top Course Bituminous Macadam - Mixing Method, Type 3.

9-36. GLASS BRICK - Glass brick shall be similar or equal to the "Argus LX - 75" type nominal 8" glass brick with fibre glass screen as manufactured by the Pittsburg-Corning Corporation.

9-37. TIMBER AND LUMBER.

(a) General. - All timber and lumber shall be straight, evensawed, sound, and entirely free from all defects which might impair its durability or its usefulness for the purpose intended.

(b) Softwood shall conform to Federal Specification MM-L-751a and Amendment 1, dated April 1938, for "Lumber and Timber; Softwood," yard lumber, grades as specified or required.

(c) Hardwood shall conform to Federal Specification MM-L-736 and Amendment 2,, dated June 1939, for "Lumber and Timber; Hardwood," yard lumber, grades as specified or required.

(d) Framing. - All Timber shall be accurately framed and fitted and securely connected as shown on the drawings. Care shall be taken in framing to work out permissible defects wherever possible.

9-38. METALLIC COATINGS.- Zinc coatings shall be applied in a manner and of a thickness and quality conforming to A.S.T.M. Specification, A-123-33 for "Zinc (hot galvanized) Coatings on Structural Steel Shapes, Plates, Bars and Their Products." Sheradizing and cadmium plating shall have thickness and durability equal to or greater than zinc coating applied as specified above.

9-39. MEASUREMENT.

(a) The weights of structural steel members and of castings will be determined from the scale weight determined in the shop before shipment, or if the scale weight is not available, certified shipping weights shall be used. The contracting officer may check these weights by calculations and no payments will be made for weight in excess of 4 percent (4%) of the theoretical calculated weight. No weight allowance for painting will be made and the cost of painting shall be included in the unit prices bit. For concrete reinforcing see paragraph 5-19(c).

(b) All other materials for which payment is not specifically provided elsewhere will be paid for on the basis of the respective unit measures, as listed in the schedules at the unit bid prices.

(c) Hardwood shall conform to Federal Specification MM-L-736 and Amendment 2, dated June 1939, for "Lumber and Timber; Hardwood", yard lumber, grades as specified or required.

(d) Framing. - All timber shall be accurately framed and fitted and securely connected as shown on the drawings. Care shall be taken in framing to work out permissible defects wherever possible.

SECTION X - PAINTS AND PAINTING

10-01. GENERAL. The requirements set forth in this section include both shop and field cleaning and painting, but only the field cleaning and painting applies to this contract on those items furnished by the Government, see paragraph 1-10. Unless otherwise specified or authorized, all paint materials shall conform to the current Federal Specifications wherever applicable. Where Federal Specifications are not applicable, material shall be as specified, or otherwise subject to the approval of the contracting officer. All colors shall be as specified or subject to the approval of the contracting officer. All paint, when applied, shall provide a satisfactory film and a smooth even surface, except when sand reinforced, and undercoats shall dry without excessive gloss, suitable for the proper application and adhesion of subsequent coats, as approved by the contracting officer. Where necessary, in the opinion of the contracting officer, to suit the conditions of surface, temperature, and weather existing at the particular time of application, the packaged paint may be thinned by the addition of not more than one pint per gallon of mineral spirits (paragraph 10-10(a)) immediately prior to application, provided that in no case shall the viscosity of the paint be reduced to a point where the specified maximum coverages will be exceeded. To distinguish several paint coats of the same color the contracting officer may require the addition of carbon black to give each coat a different shade.

10-02. SURFACE CLEANING AND PREPARATION.

(a) Shop Cleaning. - All ferrous surfaces to be painted shall be thoroughly cleaned of all millscale and other foreign substances to base metal, by sandblasting or any other method approved by the contracting officer.

(b) Field Cleaning. - All painted ferrous surfaces to be repainted which are not in contact with headwater shall be cleaned and dirt, oil, or other foreign substance shall be removed by mineral spirits or other approved cleaning agents, immediately prior to the application of field coats. All blisters and breaks in the paint film shall be cleaned to base surface by wire brush or scraper. Surfaces in contact with headwater shall be cleaned of all paint, rust, dirt, and other foreign matter by sandblasting.

(c) Protection of Surfaces. - Care shall be taken to adequately protect all machinery parts, threads, and finished surfaces during cleaning and preparation.

(d) Inhibition. - All surfaces cleaned by sandblasting, or equally effective method, shall be treated with a chemical rust inhibitor (paragraph 10-07.). The inhibitor shall be applied as soon after cleaning as practicable, and prior to formation of any forms of corrosion from atmospheric moisture, or other causes. The inhibitor shall be applied by brush and permitted to dry. This chemical inhibitor however, shall be applied only under conditions such that the temperature of the surfaces to which applied and the air in contact therewith, are between 50 degree F. and 110 degrees F., in order to insure proper chemical reaction with the metal. After drying, any unneutralized reactive residue on the surfaces shall be removed by thorough wiping with wet cloths. The inhibited surfaces shall then be permitted to dry thoroughly and shall be brushed with a broom to remove the dry dusty reaction product, after which a standard priming coat of paint, as indicated, shall be applied as soon as practicable, but in any event prior to deterioration or destruction of the inhibited surface. Should the inhibited surface be damaged or

destroyed at any point by any means whatsoever, the surfaces shall be cleaned and retreated in approved manner prior to application of the paint.

10-03. PAINT APPLICATION.

(a) All painting shall be done in a neat, thorough and workmanlike manner. Except where otherwise specified or specifically directed, all paint coats shall be applied by either brush or spray in such manner as to produce an even coating of uniform thickness completely coating all corners and crevices. All painting shall be done by thoroughly experienced workmen. Care shall be exercised during spraying to hold the nozzle sufficiently close to the surfaces being painted to avoid excessive evaporation of the volatile constituents and loss of material into the air. Paint shall be applied only to surfaces that are thoroughly dry and only under such combination of humidity and temperatures of the atmosphere and surfaces to be painted as will cause evaporation rather than condensation. A practical test is to wipe a damp cloth on the surface to be painted. If the moist streak dries promptly, conditions conducive to evaporation prevail. In no case shall any paint be applied to surfaces upon which there is frost or moisture condensation, or during rainy or misty weather, without suitable protection as approved by the contracting officer. Painting during unfavorable weather conditions shall be carried on under a protective covering. While any painting is being done, the temperature of the surfaces to be painted and of the atmosphere in contact therewith shall be maintained at or above 50 degrees F. All paint when applied shall be approximately (within fifteen degrees of) the same temperature as that of the surface on which it is applied. Where protection is provided for paint-surfaces, such protection shall be preserved in place until the paint film has properly dried and removal of the protection authorized by the contracting officer. Items which have been painted shall not be handled, worked-on or otherwise disturbed until the paint coat is completely dry and hard. After delivery at the site of permanent erection or installation, all shop-primed metal work shall be kept clean and free from corrosion. The surfaces shall be repainted or retouched from time to time, when in the opinion of the inspector it becomes necessary, using the same type of paint as the priming coat. Where field-painting at the site has been commenced on any portion of the work, the complete painting operation, including priming and finishing coats, on that portion of the work, shall be completed within 30 days after the date of such commencement. All coats on all painted surfaces shall be unscarred at the time of application of all succeeding coats, and when in the opinion of the contracting officer it becomes necessary, all coats shall be maintained by retouching or repainting, using the proper paints for the respective coats. After completion of painting, all glass, woodwork, and hardware and other surfaces not required to be painted shall be cleaned to the satisfaction of the contracting officer.

(b) Coverage. - The surface area covered per gallon for each type of paint specified shall be not greater than the following:

On smooth metallic surfaces:

1st Priming Coat	600 square feet
2nd Priming Coat	425 " "
1st and 2nd Finish Coats	550 " "

On sanded priming coat:

Sanded Primer Coat	425	square feet
1st Finish Coat	250	" "
2nd Finish Coat	300	" "
3rd Finish Coat	400	" "

10-04. PRIMING COATS.

(a) Unpainted Surfaces. - The surfaces of all ferrous metal work to be embedded in the concrete, machined surfaces, surfaces requiring welding, and surfaces which will be in riveted contact shall not be painted unless otherwise specified.

(b) Structural Parts not subject to erosion, abrasion, or severe wear shall receive one shop and one field priming coat.

(c) Spillway Gates which are to be used for diversion shall be painted with two shop coats of Synthetic Red Lead Primer. Those gates not to be used for diversion shall receive one shop coat of Synthetic Red Lead Primer.

(d) Exterior Exposed Surfaces subject over extended periods of time to immersion in water, erosion by water, or to other abrasive action; namely, the upstream face of all gates and other areas in contact with headwater, shall be treated as follows: After thorough removal of the protective shop coat of paint, dirt, rust, and other foreign matter, the surfaces shall be reinhibited and painted with one coat of Synthetic Red Lead Primer. In this coat, a heavy uniform course of perfectly clean sand (see paragraph 10-11(f)) shall be thoroughly and uniformly embedded within 15 minutes after application of the paint, or in any event before the paint has set to such extent as to prevent the proper embedment and adhesion of the sand particles. The sand shall be applied by air spray at reduced pressure or in any other manner which will insure thorough embedment of the maximum volume of sand particles without appreciable movement of the paint film. This coating shall be allowed to dry for a minimum of 48 hours prior to application of finish coats.

(e) Machinery and Mechanical Equipment (except threads and finished surfaces) subject to exterior atmospheric exposure, shall receive one shop-priming coat and a second field-priming coat after final erection in place in the structure. All shop-primed surfaces which will be inaccessible after fabrication shall receive an additional field-priming coat before assembling.

(f) Interior Machinery, Mechanical, and Electrical Equipment shall receive at least one priming coat of an approved synthetic-varnish paint compatible with the synthetic enamel approved for finish coats.

(g) Machined Surfaces shall, immediately after final inspection be thoroughly cleaned of all foreign matter and coated with Rust Preventive Compound, U. S. Army Specifications 2-84A.

(h) Screw Threads shall be protected by a coating of heavy oil.

10-05. FINISH COATS.

(a) General. - Unless otherwise specified or authorized, the sand reinforced primed metal shall be given three coats of gray enamel finish paint. Exposed primed surfaces of all other metal work shall receive 2 coats of gray enamel finish paint. The priming coat over which it is applied shall be thoroughly dry and hardened, and at least a 24-hour interval shall be allowed between two successive finish coats

and not less than 5 days for hardening of the final coat before being submerged in water. In any case, all finish painting shall be completed within 30 days after application of the first field-priming coat.

(b) Interior Mechanical and Electrical Equipment and parts for installation within buildings, and not subject to either water or atmospheric exposure, shall, unless otherwise specified or authorized, receive two coats of Heat Resistant Primer and Finish-Metal, except that parts not subject to temperature in excess of 150° F, may be given two coats of a high quality synthetic resin enamel, similar and equal to "Lustrlife" Enamel as manufactured by the St. Louis Surfacer and Paint Company, St. Louis, Missouri.

10-06. PAINTS AND PAINT FORMULAE.

(a) General. - Paints shall have the composition as indicated below and shall be of a color matching the color clips attached or as otherwise approved by the contracting officer. All paints, shall be guaranteed by the manufacturer not to gel, liver or thicken deleteriously or form gas in a closed container within a period of one year from date of manufacture.

(b) Processing of Paints.

(1) Except where otherwise specified or authorized, all paint shall be made by grinding together dry or paste pigments and a liquid vehicle to form a smooth paint that will flow freely and will not settle or react deleteriously in containers.

(2) Grinding shall produce a fineness such that coarse particles and skins will not exceed 1.5 per cent (total residue left on No. 325 mesh screen, based on pigment). The grinding shall be done in a roll or pebble mill at temperatures that will not cause polymerization.

(3) Skinning shall be negligible after exposing 6 ounces of paint in a tightly closed 8 ounce glass container to sunlight for a total time of 24 hours.

(4) The resulting paint shall have satisfactory brushing and leveling properties, shall set to touch in not less than one hour nor more than four hours, unless otherwise specified, and shall provide a satisfactory film and a smooth even surface without undue gloss, suitable for proper application and adhesion of subsequent paint coats, as approved by the contracting officer. Sufficient suitable driers shall be added to make the paint dry hard within 18 hours.

(5) In view of potential variations resulting from variable processing equipment and technique, the manufacturer may be allowed, where necessary to produce the specified viscosities, to make slight changes in formula proportions, subject to specific approval of the contracting officer.

(c) Synthetic Red Lead Primer, to be used under all gray enamel finish coats shall be composed of materials conforming, where applicable, to the specified requirements and mixed in the proportions as follows:

Red Lead	16.5% by weight
Iron Oxide	38.2%
Zinc Yellow	5.5%
Diatomaceous Silica	6.0%
Vehicle (see par. 10-06)	28.0%
Thinner	5.8%

The paint shall have a consistency of flow of between 25 and 40 seconds through the 0.15 inch diameter orifice of a standard consistency cup when tested in accordance with the procedure specified in paragraph 9 and 10 of A.S.T.M., Specification D 333-37 for "Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels." It shall have satisfactory brushing and leveling properties, shall set to light touch in not less than 2 hours nor more than 5 hours, and shall dry hard for recoating in not more than 18 hours, when tested in accordance with paragraph P-2d of Federal Specification TT-V 81a, entitled "Varnish; Mixing (for) Aluminum Paint." The vehicle shall be a **synthetic** resin varnish consisting of a phenol formaldehyde resin with the necessary oils and volatile thinners to produce elasticity, water-proofness, adherence, and durability in the finished paint film. It shall meet the detailed requirements of paragraph 10-08.

(d) Gray Finish Enamel. - Unless otherwise specified, all finish paint for all metal surfaces shall have the following composition and properties:

Coloring pigments	0.5 lbs. (approx.)
Lead Titanate	3.0 lbs.
Magnesium silicate	1.0 lbs.
Acicular Zinc Oxide	0.25 lbs.
Vehicle (see paragraph 10-08.)	1.0 gallon

The paint shall have a consistency of flow of between 18 and 40 seconds through the 0.15 inch diameter orifice of a standard A.S.T.M. consistency cup. The enamel shall have good self leveling properties and when brushed or sprayed on a vertical surface at a coverage rate of 500 square feet per gallon shall dry hard and elastic without running, streaking, or sagging.

(e) Gray Heat Resistant Primer and Finish Paint for Metal shall have the following composition:

Coloring Pigments	1.0 pound (approx.)
Titanium Dioxide	3.0 pound
Vehicle	1.0 gallon

Driers - sufficient approved driers to make the paint dry hard in 10 hours.

The vehicle shall be a glycerol-phthalate resin varnish of the following composition:

Glycerol-Phthalate Resin Solution	3/4 gallon
Mineral Spirits	1/4 gallon

The glycerol-phthalate resin solution shall consist of 70 per cent by weight of glycerol-phthalate resin dissolved in 30 per cent by weight of xylol and shall be similar and equal to "Rezyl" No. 110, Solution No. "C", as manufactured by the American Cyanamide & Chemical Corporation, 30 Rockefeller Plaza, New York, N. Y.

10-07. CHEMICAL RUST INHIBITOR, to be used where specified or required, shall be an approved compound of water, a wetting agent, a viscosity agent, phosphoric acid, and sodium dichromate. The concentration of the solution at the time of application shall be such that the Orthophosphoric acid (H_3PO_4) content shall be between 7.0 and 9.0 per cent (by weight) and the Sodium Dichromate approximately 0.75 **per cent.**

Commercial chemical rust inhibitors of composition somewhat different from this may be acceptable in lieu thereof, subject to approval by the contracting officer of results of approved tests showing that the inhibitor, when applied in accordance with instructions of the manufacturer, will identically affect ferrous surfaces as the specified compound in the following ways..

(a) Chemically react with rust and surface metal to etch the surface, form a dull grayish coating of iron-chromate-phosphate, and produce a rust-inhibited surface receptive to the firm bonding of the priming paint.

(b) After initially being thoroughly dried, the inhibited surface shall show no deleterious rusting when subjected to light rain or to other dampening agency for a period of not less than 4 hours.

(c) Leave no unneutralized active chemicals on the surface.

10-08. PHENOLIC RESIN VARNISH VEHICLE shall conform to the following requirements:

(a) Oil-resin ratio shall be 33 gallons of oil to 100 pounds of resin.

(b) Shall be clear and transparent and entirely free from resin, estergum or other non-phenolic resins. Not less than 50 per cent by weight of the vehicle shall consist of non-volatile oil and resin.

(c) The resin content shall be 100 per cent para phenyl phenol-formaldehyde condensate similar and equal to Bakelite BR 254, and shall conform to the current U. S. Navy Department Specification 52R10 entitled "Resin Phenol-Formaldehyde."

(d) The volatile thinner shall contain not more than 80 per cent mineral spirits and not less than 20 per cent high flash coal tar naphtha or high flash hydrogenated petroleum naphtha and shall be free from toxic hydrocarbons such as benzol.

(e) The oil content shall be a ternary oil mixture composed of 40% linseed, 30% liquid oiticica, and 30% "dehydrated" castor oil.

(f) The flash point shall be not below 30° C. in a closed cup tester.

(g) Shall pass a Kauri Reduction Test of 120 per cent, using the method described in paragraph F-2g, Federal Specification TT-V81, for "Varnish; Mixing (for) Aluminum Paint."

(h) Shall show no skinning after 48 hours in a 3/4 filled, tight container.

(i) Flow-out films on tin plate panels dried 72 hours shall withstand immersion in cold water for 96 hours, and in distilled water at 200° F. for 7 hours without showing more than a slight haze which shall disappear within one hour, and shall show no other signs of deterioration. The panel shall be allowed to dry and cool for 15 minutes after removal from hot water and shall then be inspected for signs of failure.

10-09. PIGMENTS.

(a) Carbon Black shall conform to either Federal Specification TT-B-601, entitled "Boneblack; Dry, Paste-in-Japan, Paste-in-Oil" or Federal Specification TT-L-71 entitled "Lampblack; Dry, Paste-in-Japan, Paste-in-Oil."

(b) Lead Titanate shall be similar and equal to Titanox "L"

as manufactured by the Titanium Pigment Corporation.

(c) Red Lead shall conform to Federal Specification TT-R-191a (97) per cent Grade for "Red Lead; Dry and Paste-in-Oil."

(d) Iron Oxide shall contain not less than 98 per cent Fe_2O_3 and shall not contain any organic coloring matter.

(e) Diatomaceous Silica shall be an approved commercial grade.

(f) Zinc Yellow shall contain not less than 40 per cent CrO_3. It shall be a basic zinc potassium chromate, soluble in acetic acid, free from lead compounds, and containing no added zinc oxide, and shall be stable or non-reactive with the pigments and vehicles specified.

(g) Titanium Dioxide shall be similar and equal to either "Ti-Pure O" as manufactured by Krebs Pigment & Color Corporation of "Titanox NC" as manufactured by the Titanium Pigment Corporation.

10-10. THINNERS AND SOLVENTS.

(a) Mineral Spirits shall have the following properties:

Gravity	43-47 degrees Baume
Flash Point (Closed cup)	100 degrees F. Min.
Initial Boiling Point	300-310 degrees F.
End Point	405 degrees F. Max.
A.S.T.M. Copper Strip Test	Negative
Solvency (Kauri-Butanol)	41 cc (a) 77 degrees F. Min.

(b) Dipentine shall have the following properties:

	Maximum	Minimum
Specific Gravity at 15.5° C.	0.854	0.845
Refractive Index at 20° C.	1.477	1.472
Unpolymerized Residue (percent (38^N H_2SO_4)	2.5	
A.S.T.M. Distillation Range:		
5% Distilling at	173 degrees C.	
10% Distilling at	175 degrees C.	
97% Distilling at	188 degrees C.	
Color-Lovibond 500 Amber	3	

Appearance: Clear and free from suspended matter.

(c) Toluol shall conform to U. S. Navy Department Specification 52T7 entitled "Toluene (Toluol)", except that it shall have a solvency (Kauri-Butanol Method) of not less than 100 cc, at 77° F.

(d) Xylol shall conform to A.S.T.M. Specification D364-36 for "Industrial Xylene (Xylol) or 'Solvent Naphtha'", except that it shall have a solvency (Kauri-Butanol Method) of not less than 93 cc. at 77° F.

(e) Normal Butyl Alcohol (Butanol) shall conform to A.S.T.M. Specification D304-33 for "Butanol (Normal Butyl Alcohol)."

(f) Ethylene Glycol Moncethyl Ether shall conform to A.S.T.M. Specification D331-35 for "Ethylene Glycol Monoethyl Ether."

10-11. MISCELLANEOUS MATERIALS.

(a) Oil, Linseed JJJ-O-331 for "Oil; Linseed, Boiled," or JJJ-O-336, for "Oil; Linseed, Raw," as specified or required.

(b) Insulating Varnish, U. S. Navy Department Specification 52-V-13b, entitled "Varnish; Insulatin, (for) Electrical Purposes."

(c) Creosote Paint for surface treatment of timber shall conform to Federal Specification TT-W-561a, entitled "Wood-Preservative: Creosote (for) Brush and Spray Treatment."

(d) Ortho-Phosphoric Acid (H_3PO_4), shall be a commercially pure product, in liquid form, containing not less than 75 per cent H_3PO_4.

(e) Sodium Dichromate, ($Na_2Cr_2O_7 \cdot 2H_2O$) shall be a commercially pure product in crystalline form containing not less than 85 per cent $Na_2Cr_2O_7$.

(f) Sand shall be perfectly clean, dry, de-dusted, silica sand particles, graded so that not more than 5% will be retained on a No. 30 mesh sieve and not more than 5% will pass a No. 50 mesh sieve, and shall be obtained by a wet-washing process.

10-12. INSPECTION.

(a) Unless otherwise specifically authorized, inspection of all materials for the paints and chemical rust inhibitor and the manufacture thereof, will be made by a representative of the contracting officer. All samples of materials and of the finished processed products will be tested and analyzed for conformity with the specifications by the Government. The inspector will collect for testing, samples of each of the materials to be used in the manufacturing processes and will then seal the material containers until test results from the samples indicate that the various materials conform to specifications. He will witness the breaking of the seals on the approved material containers and the compounding of the materials for the product being manufactured, will collect samples of the finished product for testing, and will witness the placing, sealing, and labeling of the finished product in containers for shipment. After the finished products have successfully passed the prescribed test, shipment of the sealed containers will be authorized.

(b) In the case of ready-mixed and packaged paints of standard manufacture, other than those specified by trade name, the contractor shall furnish a sample in the standard stock package, together with a certified copy of the complete chemical analysis, for test and approval by the contracting officer.

10-13. PAINT FOR MAINTENANCE. - To insure that paint used for maintenance after completion of the work shall match the original, the contractor shall furnish to the Government not less than one gallon and not more than ten gallons of each color used. The quantity of each color furnished shall be determined by the contracting officer from consideration of the severity of usage to which the surface on which it is applied is likely to be subjected.

10-14. PAINT SCHEDULE.

(a) Metal work shall be treated and painted as outlined in the following paint schedule. Items requiring painting that may not be specified or listed shall be painted as directed by the contracting officer.

(b) The different pipes and conduits in the galleries of the dam, and pipes in the service bays will be painted a different color for each class of service as approved by the contracting officer.

PAINT SCHEDULE

	SHOP SURFACE PREPARATION & PAINTING			FIELD SURFACE PREPARATION AND PAINTING				
	Sand Blast	Inhibitive Wash	Primer	Wire Brush and Wash With Mineral Spirits	Sand Blast & Inhib. W.	Primer	Two Finish Coats	Extra Finish Coat
PARAGRAPH REFERENCE	10-02(a)	10-02(d)	10-04	10-02(b)	(b) 10-02(c)	10-04	10-05	
Pipe Railing & Chains; Exterior	No	No	Red Lead	Yes	No	Red Lead	Gray Enamel	None
Steel Ladders	No	No	"	Yes	No	"	"	"
Steel Doors, Pier Houses Adits & Inside Closet	No	No	"	Yes	No	"	"	"
Gantry Cranes & Fixed Hoists	Yes	Yes	"	Yes	No	"	"	"
Flagpole	Yes	Yes	"	Yes	No	"	"	"
Manhole Covers & Frames	No	No	"	Yes	No	"	"	"
Water Piping (Exposed)	No	No	"	Yes	No	"	"	"
Hanger Bolts	No	No	"	Yes	No	"	"	"
Rabbet Angles & Miscellaneous Ferrous Metal	Yes	Yes	"	Yes	No	"	"	"
Spillway Gate Guides, Towers, Sills, Track, & Guide Rails; Exposed Parts	Yes	Yes	"	Yes	No*	"	"	"
Spillway Gates to be used in Diversion	Yes	Yes	Two Coats Red Lead	Downstream Face	Upstream Face	"	"	Gray Enamel Upstr. Face
Spillway Gates not used in Diversion	Yes	Yes	Red Lead	"	"	"	"	"
Spillway Bridge Girders	No	No	"	No	Yes**	None	None	None

* All areas exposed to headwater excepting guide rails and finished machine surfaces shall be sandblasted, inhibited, and painted with 1 coat of primer reinforced and 3 coats of gray finish enamel.

** Sandblast only.

10-15. PAYMENT for all paint and painting will be included in the contract price for the respective metals or items painted.

SECTION XI - PIER HOUSES AND GUARD HOUSES

11-01. GENERAL.

(a) Two pier houses, one at each end of the spillway bridge, shall be constructed to the limits and details as shown on the drawings. The pier houses will include the masonry and reinforcing steel outside the construction joints at the dam section proper; all windows, doors and frames, stairways and railings, roof complete, scuttles, ventilators, roof drains and drainage lines, flag poles complete, embedded metal parts for the elevator, embedded conduits for electric wiring and telephone, and all other items necessary for the completion of the pier houses as indicated on the drawings or as otherwise directed by the contracting officer.

(b) Four guard houses, two at each end of the concrete dam, shall be constructed to the limits and details as shown on the drawings. The guard houses will include the masonry and reinforcing steel beyond the end of the dam proper and above the creep keys; all windows, doors and frames, stairways and railings, roofs complete, roof drains and drainage lines, ventilators, flag poles complete, embedded conduits for electric wiring and telephone, and all other items necessary for the completion of the guard houses as indicated on the drawings or as otherwise directed by the contracting officer.

(c) Materials and workmanship shall conform to the requirements of these specifications.

11-02. WALLS.

(a) General. - The walls shall be constructed of Class "A" reinforced concrete over keyways in and tied to the concrete dam section, and all necessary sleeves or other openings, embedded conduit, pipe, and anchor bolts shall be provided as shown on the drawings.

(b) Finishing. - The interior and exterior wall surfaces of the pier and guard houses shall be finished in accordance with paragraph 5-11.

11-03. ROOFS.

(a) General. - The roofs shall consist of a Class "A" reinforced concrete slab with a wood float finish and shall be sloped to drain as shown on the drawings. The entire surface shall be covered with 2 inches of sawdust concrete conforming to the requirements of paragraph 5-17 and a 4"x4" fillet strip of sawdust concrete shall be constructed around the perimeter of the roof. The surface of the sawdust concrete shall be smooth, firm and free of all loose material and shall be dry before application of roof finish.

(b) Roof Finish. - Four layers of 15-pound asphalt-saturated felt, 32 inches wide, each laid in a heavy mopped coat of pitch shall be placed on top of the sawdust concrete, each lapping the layer below by 24-1/2 inches, and extending to the top edge of the 4"x4" fillet strip, see paragraphs 9-32 and 9-33. The roof shall then be covered with not less than 400 pounds per 100 square feet of washed and screened gravel of approved size, embedded in a heavy uniform coat of hot pitch. No work shall be executed when the temperature is less than 50° F. The completed roof shall be similar and equal to roofs constructed in conformity with Barrett Type AA specifications.

(c) Flashing. - Flashing shall consist of 4 layers of 15-pound asphalt-saturated felt laid in flashing pitch and a finish layer of mineral surface roofing felt, the upper edges of all to be embedded in a suitable

flashing groove and cemented in place with pitch of suitable character.

(d) Drains. - A sump type cast iron roof drain with dome type strainer, similar and equal in quality to Type 413S of Josam Manufacturing Company with gravel stop and clamping ring, shall be installed in each roof. A 3-inch wrought iron pipe shall be installed and connected to the roof drain as shown on the drawings.

11-04. FLOORS. Floors shall be as specified in paragraph 5-15(b), finished to a smooth, hard and true surface.

11-05. BALCONY. The balcony on each pier house shall be constructed as shown on the drawings. A steel railing of ornamental design as shown on the drawings and as described in paragraph 14-13 shall be provided and installed.

11-06. DOORS AND FRAMES.

(a) General. - Doors and frames shall be of the hollow steel type, with steel panels or glazed sash in accordance with details and sizes shown on the drawings, and shall be of first-class materials and workmanship in every way. The thickness of the metal for the various doors and frames shall be as shown on the drawings. Corners shall be mitered, welded, and ground smooth to produce indiscernible joints. Frames and doors shall be reinforced and provided with recesses, cutouts, drilled or tapped holes, etc. as required to suit the hardware applied. The parts of the doors shall be so constructed as to be proof against water entering and being retained inside the tubular rails and stiles. Doors shall have beveled edges on the lock stiles. The frames shall be securely anchored to the masonry. Doors and frames shall be set plumb and square and the doors shall fit perfectly. All exterior door frames shall be caulked against the masonry with an approved caulking compound. "Vulcatex" or equal, of color to match concrete.

(b) Weather Stripping and Thresholds. - All exterior doors shall be rendered thoroughly weather-tight by the installation of brass threshold and spring bronze weather stripping, as approved by the contracting officer. At the bottom of the doors the weather-stripping shall be of a pattern made to interlock with the threshold. The weather-stripping shall be held in place with hard metal screws and so designed and installed as to offer no reduction in the effective size of the door opening.

(c) Hardware. - Finish hardware shall be of heavy construction and suitable for the doors on which it is to be used, and shall conform to requirements of paragraph 9-30. All hardware shall be fitted at the factory in a neat and workmanlike manner. Hinges shall be of wrought bronze with ball bearings. All doors shall have cylinder locks with 5 pin tumblers, with four keys for each lock, and with four master keys, keyed to all locks. Double doors shall have top and bottom flush bolts. Exterior doors shall be provided with door stops with hooks, bumpers, and keepers. Exterior doors at deck level (Elevation 257) shall be provided with door closers Type 3000, size V, Federal Specifications FF-H-121a. Each screen door shall have brass or bronze hinges, latch with handle or knob and a screen door closer and check.

11-07. WINDOWS. Windows in the guard houses shall be steel sash of the casement type similar and equal to those manufactured by the Detroit Steel Products Company, and shall be provided with suitable hinges, catches, and handles for their proper operation. They shall be set into place with expansion plugs or be grouted as shown on the drawings, and caulked from the

outside with an elastic caulking compound similar and equal to "Vulcatex" of a color to blend with the concrete.

11-08. GLAZING. All doors and window sash shall be glazed with Type B, double strength, "A" quality glass prior to the application of the finish paint coats. Glass shall be set from the outside and embedded in special steel sash putty to avoid direct contact with steel, Glass in window sash shall be held in place with spring steel wire glazing clips, and in door sash by glazing angles neatly mitered at corners and secured to sash with bronze bolts and nuts. The putty shall be cut flush on the interior and pointed neatly on the exterior. After completion of painting, the glass shall be cleaned of all paint, putty and other marks in a manner satisfactory to the contracting officer.

11-09. SCREENS.

(a) General. - Metal screens shall be installed at the windows and doors in the guard houses and at the doors at the level of the deck (Elevation 257) in the pier houses. The frames shall be of steel tubular construction, thoroughly welded and reinforced at all corners so as to prevent water entering the tubes. Frames shall be of such size as to give sufficient stiffness and rigidity to hold the wire cloth tight. All screens shall be so constructed as to cover the opening as a single unit, without the use of separate filler plates or other loose pieces. Wire screen cloth shall be of copper or bronze wire, with 16 meshes to the inch, and shall be neatly and securely attached to the frames by metal splines which shall be so constructed as to be easily removable for rewiring.

(b) Window Screen. - Window screen frames shall be of not less than No. 24 U. S. Standard Gage Steel. They shall be complete with all necessary bolts, clips, and catches.

(c) Screen Door. - Screen door frames shall be of not less than No. 18 U. S. Standard Gage steel, and shall have 2 tubular cross rails besides the top and bottom rails. One shall be located approximately 12 inches from the bottom and the other opposite the middle rail of the steel door. The space between the 2 bottom cross rails shall be filled with a metal kick plate of not less than No. 18 gage. The wire screen cloth below the middle rail shall be protected by an interlocked bronze ribbon grille. Hardware shall be as specified in paragraph 11-06(c).

11-10. GLASS BRICK. Glass brick conforming to the requirements of paragraph 9-36 shall be installed as shown on the drawings in accordance with best standard practice and the manufacturer's recommendations. The materials to properly install the glass brick shall be approved by the contracting officer and shall include all expansion joint strips, oakum packing, felts, shearlock bars, wall ties, wall anchors, caulking, asphalt emulsion, and any other materials necessary for a complete installation.

11-11. STRUCTURAL STEEL AND MISCELLANEOUS IRON.

(a) Safety Treads. - Safety treads conforming to the requirements of paragraph 9-03 shall be furnished and installed on all stairs as indicated on the drawings.

(b) Handrailing. - Handrailing conforming to paragraph 14-01 shall be furnished and installed as indicated on the drawings.

(c) Miscellaneous. - Embedded piping and conduits, miscellaneous anchor bolts and other miscellaneous metals which are not furnished by others shall be furnished and installed as indicated on drawings and in accordance

with the specifications for the various metals as stated in Section IX.

11-12. VENTILATORS, SCUTTLES AND FLAGPOLES.

(a) Ventilators. - Six 12-inch roof ventilators of 16 ounce copper, equipped with necessary operating chain and hardware similar and equal to "Royal Double Cone Ventilator" as manufactured by the Royal Ventilator Company, shall be furnished and installed, one on the roof of each pier house and guard house, as indicated on the drawings.

(b) Scuttles. - Two 26-inch by 30-inch scuttles, similar and equal to "Bildrite" All-Steel Watertight Roof Scuttle as manufactured by William R. Edmister & Sons, Columbus, Ohio, shall be furnished and installed, one on the roof of each pier house, as indicated on the drawings. The frame shall be of 14 gage and the cover of 10 gage copper-bearing steel, and both frame and cover shall be insulated.

(c) Flagpoles. - Six tapered steel tubing flagpoles similar and equal to "Conetapered 'C' Type, heavy," as manufactured by The Pole and Tube Works, Inc., Newark, New Jersey, shall be furnished and installed complete, one on each pier house and guard house, as shown on the drawings. Each flagpole shall be fitted with a gold leaf covered copper ball, ball-bearing revolving bronze truck and 1/4 inch flexible steel rope halyards with flag snaps. Galvanized cleats shall be attached to the poles for the pierhouses and bronze cleats shall be mounted on the concrete walls for the guard house flagpoles. Mountings which attach the flagpoles to the masonry shall be of cast bronze.

11-13. PAINTING. Painting shall be in accordance with the requirements of Section X except as otherwise specified herein. Colors of all finish coats shall be subject to the approval of the contracting officer.

11-14. PAYMENT.

(a) Concrete. - Payment for concrete in the pier and guard houses will be made at the applicable contract unit price per cubic yard for "Concrete, Class A", or "Concrete, Class B".

(b) Roof Surfacing. - Payment for roof surfacing as specified in paragraph 11-03 will be made at the contract unit price per square for "Roof Surfacing," and shall include furnishing and installing the sawdust concrete, pitch, felt, gravel, and all work necessary for the proper placing thereof. No deductions for openings less than 15 square feet will be made.

(c) Roof Drains. - Payment for furnishing and installing roof drains will be made at the contract unit price each for "Roof Drains".

(d) Doors and Windows. - Payment for furnishing and installing doors and frames, steel sash, screen doors and window screens, complete with hardware, weather stripping, thresholds and glazing, will be made at the contract unit price per pound for "Doors and Windows; Steel".

(e) Glass Brick. - Payment for furnishing and installing glass brick as specified in paragraph 11-10 will be made at the contract unit price per square foot for "Glass Brick", and shall include all work and materials necessary for the complete installation of the glass brick.

(f) Safety Treads. - Payment for furnishing and installing safety treads will be made at the contract unit price per pound for "Safety Treads".

(g) Handrailing. - Payment for furnishing and installing pipe

handrailing will be made at the contract unit price per linear foor for "Handrailing; Steel Pipe", in conformity with paragraph 14-01(b).

(h) Structural Steel and Miscellaneous Iron. - Payment for furnishing and installing structural steel and miscellaneous iron described in paragraph 11-11(c) will be made at the contract unit price for the applicable type and material as described in Section XIV.

(i) Ventilators. - Payment for furnishing and installing roof ventilators will be made at the contract unit price each for "Roof Ventilators".

(j) Scuttles. - Payment for furnishing and installing scuttles will be made at the contract unit price each for "Scuttles".

(k) Flagpoles. - Payment for furnishing and installing flagpoles complete with fittings will be made at the contract unit price each for "Flagpoles".

SECTION XII - GOVERNMENT FIELD OFFICE

12-01. GENERAL. - The contractor shall construct a temporary field office for use by the field force of the contracting officer, complete and ready for occupancy in accordance with the drawings and specifications. The contractor shall complete the field office to such extent as will permit occupancy within 30 calendar days after date of receipt of notice to proceed, and the entire building complete with all fixtures and installations shall be completed within 60 calendar days after receipt of notice to proceed. The building will be located at a site to be selected by the contracting officer after award of the contract. It is the intent of the Government to locate the building in the proximity of the contractor's office and shops at the site of the work. All materials specified shall conform in all respects to current Federal Specifications whenever applicable. All other materials shall be as specified or otherwise required by the contracting officer.

12-02. FEDERAL SPECIFICATIONS. - Applicable Federal Specifications for materials required for the field office are as follows:

FEDERAL SPECIFICATIONS

Material	Serial Number	Title
Galvanized Iron	QQ-1-696	Iron and Steel; Sheet; Black and Zinc-Coated (Galvanized).
Steel Pipe	WW-P-403a	Pipe; Steel and Ferrous Alloy, Wrought, Iron-Pipe-Size
Glass	DD-G-451	Glass; Flat (for) Glazing Purposes
Lumber	MM-L-751b	Lumber and Timber; Soft-wood
Magnesia	HH-M-61	Magnesia; Block, Cement, and Pipe Covering (Molded)
Pipe - Soil	WW-P-401	Pipe and Pipe-Fittings; Soil, Cast-Iron
Pipe-Fittings	WW-P-501a	Pipe - Fittings; Cast-Iron (threaded)
" "	WW-P-521a	Pipe- Fittings; Malleable - Iron (threaded) 150 pounds
Roofing	SS-R-521	Roofing and Shingles; Asphalt Prepared, Mineral-Surfaced
Plumbing	WW-P-541a	Plumbing - Fixtures; (for) land use
Putty	TT-P-791a	Putty; Pure-Linseed Oil, (for) Wood-Sash Glazing
Venetian Blinds	LLL-B-441	Blinds; Venetian, Wood-Slat (Type I)
Sheathing Paper	UU-P-536	Paper; Sheathing, Waterproof
Wall Board	SS-W-51a & Amendment 1 dated October 1937	Wall Board; Gypsum

12-03. EXCAVATION, FILLING AND GRADING

(a) The contractor shall make the necessary excavation for the parking lot area, foundation, footings, fuel tank, septic tank, pipings and drains as shown on the drawings. The contractor shall construct a parking space adjacent to the field office large enough to accommodate 15 automobiles; the area shall be graded, all rock or other obstructions removed, and the area covered with compacted bank run gravel to a minimum depth of 6 inches. The contractor shall provide suitable gravel surfaced driveways from the parking area to the contractor's access road; gravelled walkways necessary for access from office to parking area and roadways in the vicinity. All walkways shall be covered with 3 inches of rolled bank run gravel fill, built to line and grade as staked in the field.

(b) Furnace Room. - The foundation area covered by the furnace room shall be stripped to a depth sufficient to remove all vegetable matter, then refilled and tamped with pervious material as directed by the contracting officer, to a grade 4 inches below the floor grade as shown on the drawings.

12-04. FOUNDATION. - The foundation and footings shall be of Class "B" concrete, having 1-1/2 inch maximum size aggregate, in accordance with Section V of these specifications, constructed to line and grade as shown on the drawings. The foundation posts shall rest on the footings and after being set to exact line and grade shall be anchored into place by backfill thoroughly tamped in thin layers to the height of finished grade as shown on the drawings. The girders supported on top of the posts and foundation shall be securely anchored thereto by bolting as shown on the drawings. Bolts in the foundation shall be placed during concreting operations.

12-05. CONCRETE FLOORS. - The floor in the furnace room shall be of Class "A" concrete, in accordance with Section V of these specifications, 4 inches thick, trowelled level, smooth and to a straight edge, or as specified. The furnace room floor shall have floor drain and trap located as shown on drawings, set 1 inch below floor grade and the floor trowelled smooth and to a straight edge from the drain to floor grade at each side. Reinforcing for concrete floors shall be 4-inch by 12 - inch welded wire fabric of No. 10 and No. 12 wire gage.

12-06. FRAMING. - Lumber for framing shall be equal to No. 2 common fir. It shall be thoroughly seasoned, straight, even sawed, square cornered, sound and free from defects which may impair its strength, durability or its usefulness, for the purpose intended. All lumber shall be of commercial sizes, surfaced four sides unless shown or specified otherwise. The framework shall be constructed as indicated on the drawings and shall be erected in a substantial manner. Studding shall not be spaced over 16 inches on centers for exterior walls and not ever 24 inches on centers for interior walls, doubled at all openings larger than the normal spacings and when cutting through joists, or rafters, headers shall be provided to double the framing around the openings. Double studs shall be provided at all corners of the building. Knee braces shall be provided from the corner studs to the fifth stud, diagonally from bottom plate to top plates at all corners of the building. Ridge board shall be provided at the ridge of the roof. All spiking of assembled members of framing shall be clinched by not less than 1/4-inch. Rafters and ceiling joists shall be spaced at 24-inch centers or as shown on drawings.

12-07. FLOORS. - Subflooring shall be nominal 1" x 6", 1" x 8", or

1" x 10" boards, S4S, laid diagonally with 1/16-inch joints between boards and nailed to each joist with two 10d nails for boards 6 inches wide or three 10d nails for boards wider than 6 inches. Nail heads shall be driven below the surface of the boards. Asphalt saturated felt weighing 15 pounds per 100 sq. ft. shall be laid on the subfloor. The finish floor shall be 5/8" x 3" tongue-and-groove clear edge grain, kiln dried, B grade fir or equal, and shall be driven up tight, blind nailed, sanded, and oiled as specified in paragraph 12-19. All flooring shall be satisfactorily protected from dampness and the weather before being placed. Floor joists shall be spaced on 16-inch centers.

12-08. SIDING. - The outside faces of the building shall be covered with 25/32" asphalt-covered fibre sheathing similar and equal to Johns-Manville "Weathertite," nailed securely to every 2" x 4" stud with 8d flat-headed wire nails. A layer of 15-pound asphalt-saturated felt shall be applied between the sheathing and the outside siding. The outside siding is to be asbestos-cement shingles similar and equal to Johns-Manville No. 109U, laid according to the manufacturer's recommendations.

A 20 gage corrugated galvanized iron flashing shall be run continuously along the sill of the building and buried at least 12 inches below the finished ground line. Counter flashing of 24 gage galvanized sheet iron shall be applied as shown on the drawings. All seams shall be soldered. The galvanizing shall be Class "D" - Ordinary Coating.

12-09. ROOFING. - Roof sheathing shall consist of 1-inch by 6-inch No. 2 fir or equal, matched and dressed on both sides with no beading. The roofing shall be double-coated strip shingle similar or equal to "Flintkote" roofing weighing not less than 210 pounds per square. The roofing shall be securely fastened with large headed, 3/4-inch galvanized roofing nails. All seams, nail holes and other breaks in the roofing shall be thoroughly sealed with an approved mastic roofing cement. The ridge shall be covered by a strip of roofing not less than 12 inches in width, bent over the ridge and securely sealed and nailed on each side. Galvanized iron flashing shall be provided and installed as shown on the drawings or as directed by the contracting officer.

12-10. WALLS AND CEILINGS.

(a) General. - With the exception of the bathroom and furnace room, the inside of all exterior walls, both sides of all interior walls and all ceilings shall be covered with 1/2 - inch insulating board similar and equal to "Celotex" extending from floor to ceiling, securely fastened to all bearings. One-inch quarter round mouldings shall be provided at all corners. The edges of the insulation board shall be beveled at joints.

(b) Furnace Room. - The insulating board for walls and ceilings of furnace room shall be 3/8-inch gypsum board, applied and finished in accordance with subparagraph (a), above.

(c) Walls and Ceiling; Bathroom. - The ceiling shall be covered with 1/2-inch insulating board, similar and equal to "Celotex." The inside of the exterior wall and all interior walls shall have a covering of pressed wood 1/4-inch thick similar to "Tempered Preedwood" manufactured by Masonite Corporation, extending 4'-0" above the floor. The exterior wall shall have 1/2-inch insulating board similar and equal to "Celotex" back of the pressed wood, and all walls above the pressed wood shall be covered with the same type of insulating board. Furring strips shall be used where required to make the finish surfaces of pressed wood and insulating board flush where they join each other, and the

joint shall be covered with a moulding of 1-inch by 3-inch No. 2 fir or equal. The edges of the insulation board shall be beveled at joints. One-inch quarter round shall be placed at all vertical corners and in horizontal corners along the ceiling.

(d) Shower Stall.- The contractor shall furnish and install a commercial shower stall, complete with fittings, as shown on the drawings, similar and equal to "Marine No. 15," manufactured by the Fiat Metal Manufacturing Company, Chicago, Illinois.

(e) Ceiling Insulation. - Between all ceiling joists and extending over wall plates, as shown on the drawings, a rock fiber or chemically treated wood pulp insulating material 4 inches nominal thickness shall be installed. Insulation shall weigh not more than 10 pounds per cubic foot.

12-11. EXTERIOR TRIM. - Exterior trim shall be equal to No. 2 fir, finishing stock 3/4-inch thick except as otherwise noted. Door and window castings shall be 3/4-inch by 3-1/2 inches wide. All other exterior finish shall be to size as indicated on the drawings. Insulating wool of a quality satisfactory to the contracting officer shall be placed entirely around all window frames and around the jambs and heads of all door frames as shown on drawings.

12-12. INTERIOR WOOD FINISH. - All interior wood finish shall be equal to No. 2 fir finishing stock throughout, 3/4-inch or 13/16 inch thick and of sizes as indicated on the drawings. Water closet stalls shall be 6 feet- 4 inches high finished as shown on the drawings or as directed by the contracting officer. Over each lavatory a 16-inch by 24-1/2-inch mirror with white enamel metal frame shall be installed. Instrument cabinets shall be constructed as shown on drawing or as directed by the contracting officer.

12-13. WINDOWS AND FRAMES. - Windows shall be of stock pattern, No. 2 fir, or equal, double hung sash as shown on the drawings, glazed with clear glass. Windows in bathroom shall be single sash, hinged at bottom to open inward, glazed with clear glass, and fitted with cabinet latches. All frames shall be constructed so as to receive screens or storm windows, and as shown on the drawings. All glass will be as specified in paragraph 12-02.

12-14. DOORS AND FRAMES. - Exterior doors shall be solid construction, equal to No. 2 fir, 1-3/4 inches thick, designed as shown on the drawings. The upper part shall be of glass equal to that specified in paragraph 12-02, set in place with wooden stops on the inside and securely bradded and puttied outside. Interior doors, unless otherwise specified, shall be 1-3/8 inches thick, equal to No. 2 fir and shall have five cross panels. Standard stock doors of equal quality and size will be acceptable. Doors for water closets shall be 2'-0" x 4'-6" frames made up of 3/4" x 3-1/2" framing and covered with pressed wood 1/8-inch thick similar and equal to "Tempered Presdwood" manufactured by Masonite Corporation. Doors for the instrument cabinet shall be 1'-8" x 7'- 8" as shown on drawings, made up of 1-1/8" x 3" framing and covered with pressed wood 1/8-inch thick. The interior side of the furnace room door shall be covered with 28 gage galvanized iron as shown on the drawings.

12-15. SCREENS. - All windows and outside doors shall be equipped with screens. Window screen frames shall be constructed of No. 2 fir, or equal, 1-1/8 inches thick with 2-inch side and top rails and 3-1/2 inch bottom rails, divided at the center horizontally by a 2-inch rail. Screen door

frames shall be of same material and construction as specified for windows, but with two horizontal intermediate rails, one at 2-1/2 feet and one at 3.0 feet from bottom. Standard stock screen doors of equal quality and size will be acceptable. All screen wire shall be of 16 mesh to the inch, galvanized, conforming to Federal Specification RR-C-451a for "Cloth; Wire Screen", Type "D", stretched and secured with suitable wood strips, well bradded. Suitable screens shall be placed over the bathroom windows.

12-16. LOUVRES. - Wooden louvres shall be constructed and installed at both ends of the building as shown on the drawings. Removable screens and storm protection panels shall be furnished and installed in louvres, as shown on the drawings.

12-17. VENETIAN BLINDS. - All double hung windows, except in the furnace room, shall be fitted with venetian blinds with rust proof hardware fittings, automatic cord lock stoppin device and spiral gear to tilt slats. The wooden slats shall be finished in ivory or cream color and the tape shall harmonize with the finish color of the wood. The blinds shall conform to the requirements of Federal Specification LLL-B441 for "Blinds; Venetian, Wood-Slat", (Type I).

12-18. HARDWARE. - The contractor shall furnish and install all hardware specified below. All hardware shall be accurately and securely installed. At completion, all keys shall be delivered properly labeled, to the contracting officer. All hardware shall be of stock design with sanded brass finish, and shall be of the following types, as specified.

(a) Entrance Doors.
2 sets - 1-1/2 prs. of 3-1/2" x 3-1/2" loose pin, butt hinges.
2 cylinder locks with 5-1/2" x 3-5/8" x 3/4"case.

(b) Interior Doors.
6 sets - 1-1/2 prs. of 3-1/2" x 3-1/2" loose pin, butt hinges.
6 Mortise locks with 3-5/8" x 3-7/8" case.
All locks shall be complete with two keys and approved knobs, latches and escutcheons.

(c) Windows.
100 Iron easy spring window bolts and fasteners.
2 prs. 1-1/2" x 1-1/2" tight pin, butt hings.
(Bathroom windows.)
2 - Cabinet latches. (Bathroom windows.)

(d) Water Closet Doors
2 latches and keepers.
2 prs. spring hinges (for 3/4-inch doors.)

(e) Instrument Cabinets.
4 night locks complete
4 prs. cabinet hinges (for 1-1/8-inch doors.)

(f) Miscellaneous.
54 screen hangers complete
29 - 3-inch hooks and eyes.
2 prs. screen door hinges

The contractor shall furnish and install all other hardware and minor parts that may be necessary to complete the contract.

12-19. PAINTING.

(a) Exterior. - Before applying any paint the surface to be painted shall be thoroughly dry and free from dirt, oil, grease and other foreign substances. As soon as complete the outside surfaces, of windows, doors, and screen frames shall be given one priming coat of paint, conforming to Federal Specification TT-P-362 for "Paints; Lead-Zinc-Base, Ready-Mixed and Semipaste, White and Tinted". After the priming coat has thoroughly dried, one finishing coat of white outside house paint, shall be applied to all wood surfaces, except the outside trim. All outside trim surfaces shall be painted with one finishing coat of green, medium shade, outside paint as approved. All paint for finishing coats shall be of stock No. 6 B S-W ODP White Lead as manufactured by the Sherwin Williams Company, or equal.

(b) Interior. - All interior woodwork, except floors, shall be painted with two coats of inside paint of approved manufacture and color. All finished floors shall be given one heavy coat of boiled linseed oil.

12-20. PLUMBING.

(a) All labor and materials required for installing a complete plumbing system shall be provided as indicated on the drawings and in accordance with these specifications and in accordance with any State or local regulation, and the publication "Recommended Minimum Requirements for Plumbing in Dwellings and Similar Buildings", issued by the Bureau of Standards.

(b) The plumbing fixtures and accessories shall be similar and equal to those designated below, reference being made, for identification only, to catalog numbers as listed in Kohler Co. Catalog K-39.

2 Closets, No. Brooklands K-3940-PR complete with fittings.
2 Toilet paper holders.
2 Lavatories No. Clare K-3000-P with fittings.
1 Floor drain and trap.
1 - 3'-0" Urinal - Jarves NO. K-5052-A complete with fittings.

(c) The field office shall be supplied with a constant and uninterrupted potable water supply of not less than 35 and not more than 50 pounds per square inch pressure, furnished by the contractor. The supply line shall be 3-inch pipe placed in a trench of sufficient depth and protected to prevent freezing in subzero weather. At the point of entrance, in bathroom, a main shut-off and drain cock shall be installed. Pipe sizes and valves shall be as shown on the drawings. An automatic electric hot water heater of 30-gallon capacity shall be furnished and installed. The heater shall be similar and equal to Westinghouse Electric Manufacturing Company's Square Type Electric water heater, installed to manufacturer's specifications.

(d) The contractor shall lay a 4-inch vitrified pipe sewer line from the end of the cast iron soil pipe, outside the building to the sewage disposal tank located not less than 50 feet from the building. Vitrified pipe shall conform to the requirements of Federal Specification SS-P-361 For "Pipe; Clay, Sewer". The sewer shall be laid with 1/4-inch to 1-foot pitch, true to line and grade, and made up with tight joints. The sewage

disposal tank shall be similar and equal to Kaustine Standard Series Horizontal Septic Tank No. 85, and provided with proper connections for outlet and inlet pipes. The outlet shall connect to a grid system not to exceed 780 feet of 4-inch field tile pipe including connections. The joints of the field tile pipes shall be laid open, 1/4-inch, and top half of each joint shall be covered with sheathing paper. If the field office is conveniently located, the sewer line from the Government Field Office may be connected to the sewer disposal system of the contractor's office, provided the system is designed to carry the extra sewage, subject to approval by the contracting officer.

12-21. ELECTRICAL WIRING. - The contractor shall secure all permits and give such notices as required by State and local authorities. The installation shall be in strict accordance with the National Electrical Code. The system shall be 3-wire, 220/110 volt, singlephase, solid neutral, rigid metal conduit to fuse cabinet as indicated on drawing. All wiring shall be rubber-insulated, non-metallic sheathed cable, similar and equal to "Wireflex" as manufactured by The Wiremold Co. The building shall be wired as indicated on the drawings. Three main feeders of not less than No. 8 AWG wire shall be installed in 1-inch conduit. The ground wire shall be not less than NO. 8 AWG. The entrance switch shall be outside type, 3-wire, solid neutral, 2-pole, 30-amp. Fuse cabinet shall be flush type, steel with door and built for 6 circuits, with solid neutral, motor switch. The motor switch shall be of the automatic thermal protection, reset-type. Each circuit shall be fused with 15-amp. fuses, Duplex plug receptacles or convenience outlets shall be 15-amp., 125-volt, with stamped brass plates. At completion, all circuits shall be plainly marked for identification. The contractor shall furnish and erect in first class manner, all fixtures complete with shades and lamps of the wattage indicated, fuses and all other necessary accessories. The fixtures shall be similar and equal to those designated below. Reference is made, for identification only, to catalog numbers as listed in Benjamin Electric Mfg. Co., catalog entitled "Benjamin Sockets for Reflector Fixtures".

SCHEDULE

Location No.	No.	Type
Inspector's Office	2	5642 - PUL R.L.M. Dome with canopy and fixture stud.
Clerk's Office	1	5642 - PUL R.L.M. Dome with canopy and fixture stud.
Furnace Room	1	5423 Shallow Dome with canopy and fixture stud.
Bathroom	1	5423 Shallow Dome with canopy and fixture stud.
Bedroom	1	5642 - PUL R.L.M. Dome with canopy and fixture stud.
Field Engineers Office	1	5642 - PUL R.L.M. Dome with canopy and fixture stud.
Drafting Room	3	5642 - PUL R.L.M. Dome with canopy and fixture stud.

Location No.	No.	Type
Platform	2	6821 Watertight angle with round box.

The contractor shall do all cutting and placing of supports necessary in this work.

12-22. HEATING.

(a) General.- The contractor shall furnish and install an oil burning automatic controlled furnace similar and equal to Mueller's No. 55 B. G. Fuel Oil Furnace. The installation and workmanship shall be in strict accordance with the specifications of the manufacturer, rules and regulations of the National Board of Fire Underwriters and local requirements.

(b) Grills, Registers and Ducts. - All grills and registers shall be furnished and installed by the contractor as shown on the drawings or as directed by the contracting officer. Warm air grills shall be provided with independently adjustable, manually controlled vertical fins for deflection of air. Cold air return register shall be plain lattice type, suitable for floor or wall installation and of the size indicated on the drawings. The hot and cold air duct, register and grill system shall be constructed in accordance with manufacturer's specifications, and installed as shown on the drawings or as directed by the contracting officer.

(c) Smoke Pipe and Vent. - The smoke pipe and vent shall be as specified by the manufacturer for furnace used. The smoke pipe from furnace to 2-inches above roof, shall be covered with asbestos air cell pipe covering, 1-inch thick, properly secured to the pipe.

(d) Fuel Tank. - A fuel supply tank of 500 gallons capacity shall be furnished and installed by the contractor. The tank shall be under ground and covered with not less than 2 feet of well tamped backfill. Fuel tank and all piping shall meet all requirements of the National Board of Fire Underwriters.

12-23. FIRE PROTECTION. - The contractor shall furnish and install one frost proof fire hydrant with suitable connections for two 1-1/2 inch fire hoses. The fire hydrant shall be installed not more than 25 feet from the building and shall be supplied with water at a pressure not less than 35 pounds.

12-24. FLAGPOLE. - The contractor shall furnish and erect one flagpole complete with pulley and rope, as shown on drawings. The flagpole shall be constructed of one 12-foot length of 2-1/2 inch and one 12-foot length of 2-inch galvanized steel pipe, with an overlap of 1 foot at joint, securely welded. The flagpole shall be securely fastened to a concrete base as shown on drawings and shall be so attached that bottom bolt can be removed and pole revolved about upper bolt to a horizontal position or as directed by the contracting officer.

12-25. REMOVAL OF BUILDING. - Upon completion and acceptance, the field office will become the property of the United States and will be removed by the Government. No materials or equipment shall be salvaged by the contractor.

12-26. PAYMENT. - Payment for the field office complete, including the furnishing of all labor, plant and materials necessary to complete the

building in accordance with these specifications and as shown on the drawings, and including parking area, driveways, walks, and grading around the building, will be made at the contract lump sum price for "Field Office" upon acceptance of the building by the contracting officer. The contracting officer retains the right to order the contractor to make an extension as indicated on the drawings, with similar construction and equipment as the original building. Payment for the extension, if any, will be made at the lump sum price for "Field Office Extension".

Specifications: Long Sault Dam

Section XIII - ACCESS RAILROAD AND HIGHWAY

13-01. GENERAL.

(a) Access Railroad and Highways. - The contractor shall construct a single tract access railroad, and highway (as shown on the drawings), the railroad starting from a point on a track provided by others, and the highway starting from a point on State Highway No. 37 across a bridge provided by others over Grass River, both continuing across a plug left in the Long Sault Canal to Long Sault Dam, and across the top of Long Sault Dam to a point approximately one mile beyond the concrete portion of the dam towards the powerhouse, all as indicated on the drawings.

(b) Temporary Access To Barnhart Island. - During the first stage construction for the south section of the dam, see paragraph 2-06, the contractor shall provide a single track railroad for access to Barnhart Island by means of a timber trestle to be constructed by him along the downstream ends of the spillway piers. The deck of the trestle shall be floored over to provide a single lane roadway for trucks. Immediately upon completion of cofferdam "DD" for the second stage work, he shall continue this single track line and truck road across the top of cofferdam "DD" and connect with the railroad line and highway to the powerhouse. A suitable walkway with handrail shall be built alongside the tract over the river. The contractor shall provide a minimum vertical clearance to Elevation 194 on his trestle between the spillway piers to provide a clear opening for the flow of the river after removal of the first stage cofferdams. For construction of this temporary access line the Government will furnish the necessary timber, ties, rails, bolts, spikes, tie plates, turnouts, and other appurtenances. The contractor shall furnish all the necessary equipment and labor and shall complete this temporary access line at the earliest practicable date, making the necessary connections to the permanent railroad and doing all work necessary to provide a safe and serviceable line. After the permanent line across the dam is completed and connections have been made, the contractor shall completely remove the temporary line and trestle. All the material removed, including rails and accessories, shall become the property of the contractor, and shall be disposed of or removed from the site to the satisfaction of the contracting officer.

(c) Removal of Line Across Plug in Canal. - Other contractors will complete the construction of Robinson Bay Lock, bridge, and the permanent railroad from the Long Sault Dam contractor's line south of the canal, across the lock and over Dike No. 4 to connect again with the Long Sault Dam contractor's line. The Government will furnish the turnout, switch stand and appurtenances for this connection and the Long Sault Dam contractor shall furnish all the equipment and labor to install the two connections with the permanent line mentioned above. After the permanent connection has been made, the Long Sault Dam contractor shall remove all that portion of the railroad lying between the two turnouts and passing over the plug left in the Long Sault Canal, and which is no longer required for construction purposes. All the material removed, including rails and accessories, shall become the property of the contractor, and shall be disposed of or removed from the site to the satisfaction of the contracting officer.

(d) Payment and Use of Facilities. - The railroad and highway to be constructed by the Long Sault Dam contractor will be paid for on a unit price basis for all items entering into the work as indicated in the Schedule

of Bid Items with the exceptions as follows: no payment will be made for the construction of the temporary access railroad to Barnhart Island specified in subparagraph (b) above or its removal, or for the removal of the section of railroad across the canal plug specified in subparagraph (c), and costs for this work shall be included in other applicable pay items; other contractors shall have the privilege of using any portion of the railroads and highways which have been completed as a part of this contract, and the temporary line for access to Barnhart Island and the powerhouse shall be kept open for use by the powerhouse contractors or others.

(e) Maintenance of Railroads and Highways. - The contractor shall maintain in serviceable condition, during the life of the contract, all railroads and highways built by him. In addition he shall maintain during the period it is used by him the railroad and highway referred to in subparagraph (c) which connects with his railroad and highway south of the canal and rejoins it after passing over Robinson Bay Lock at a point north of the canal as shown on the drawings. Maintenance of the track shall meet the standard requirements of the Massena Terminal Railroad and any other railroad which may operate trains over it. Maintenance of the highways shall conform to the standard practice of the State of New York Highway Department for primary highways. The wearing surface and shoulders shall be kept free of holes, ruts, cracks, boils, ravelled edges and obstructions. The wearing surface and shoulders shall be kept clear of snow and debris. When slippery conditions exist, due to ice or snow, the grades, curves, intersections and other dangerous places shall be kept sanded. Culverts, catch basins and drains shall be kept open. No separate payment will be made for any of the foregoing maintenance, the cost of which shall be included in other applicable pay items.

13-02. FORMATION OF ROADBEDS.

(a) Alignment. - The center of the roadbed for the permanent railroad and highway specified in paragraph 13-01, shall conform in alignment to that shown on the drawings.

(b) Grade Line. - The grade line on the alignment drawings for the railroad denotes sub-grade, and this term indicates the tops of embankments, cuts or fills ready to receive ballast. The grade line for the highway indicates the top of the finished roadway surface.

(c) Width of Roadbed. - When properly compacted and finished, the roadbeds shall conform to the dimensions shown on the drawings.

13-03. CLEARING AND GRUBBING.

(a) General. - The contractor shall clear the work area to be occupied by railroad and highway, as shown on sheet No. 2 of the drawings, of all buildings, fences, trees, logs, brush, crops, grasses and other perishable materials as directed by the contracting officer or as hereinafter specified. No payment for clearing, including specified grubbing, removal and storing of fences and crops, and the disposal of cleared material will be made, but shall be included in the contract unit prices for the various items of grading.

(b) Cutting and disposal of Brush. - All trees, weeds, and grass over 12 inches in height shall be cut off flush with the ground and shall be disposed of by burning or as directed by the contracting officer.

(c) Stumps. - Where clearing is done, stumps, except where they are to be grubbed out, shall be cut off even with the ground.

(d) Grubbing. - Stumps and roots more than 3 inches in diameter shall be grubbed out where they are encountered within the sections of ditches and

foundation excavations and from areas to be occupied by embankments. In foundation and embankment areas, they shall be removed to a depth of at least two feet below the original surface. Stumps and roots so removed shall disposed of by burning or as directed by the contracting officer. Depositing stumps, roots or other perishable materials in embankments will not be permitted.

(e) Salvage. - All buildings, fences, and annual crops shall become the property of the contractor and shall be disposed of by him.

13-04. EXCAVATION AND EMBANKMENT.

(a) Definition. - The term excavation and embankment as used in this section of the specifications includes all the excavation and embankment required for the construction of the railroad and highway including excavation for the construction of roadbeds, ditches, road changes, grade crossing approaches, parking grounds, signal bases and all other excavation and embankment required by the drawings and specifications or ordered by the contracting officer.

(b) Classification. - All excavation and fill specified above, which is not otherwise specifically designated herein, will be classified as "Excavation; R. R. and Highway" and "Fill, R. R. and Highway" respectively. The cost of excavating rock and gravel from borrow pits outside of roadway excavations and used for roadbed surfacing and ballast will be included in the contract unit prices for those items.

(c) Slopes for Grading.

(1) Grading shall be to the slopes shown on the drawings. Slopes will, in general, for embankments and excavations, be one and three-quarters horizontal to one vertical (1-3/4:1) unless otherwise directed by the contracting officer.

(2) Should unforeseen conditions arise or materials of unexpected nature be encountered at any time after the excavation has been started, the contracting officer may require the steepening or flattening or benching of such slopes.

13-05. EXCAVATION BELOW GRADE. - Excavation for the highway roadbed shall be carried to a depth of 15 inches below the grade line. The roadbed shall then be moistened if deemed necessary by the contracting officer and compacted to final dimensions and grades in the manner and to the density required for Class II fill as specified in paragraph 4-04. The finished roadbed for the highway shall be formed by placing 9 inches of gravel as specified in paragraph 13-11. Excavation below grade will be paid for at the contract unit price for "Excavation, R. R. and Highway."

13-06. DISPOSAL OF EXCAVATED MATERIALS. - It is intended that all suitable materials excavated from railroad and highway excavation will be placed in roadway embankments except as provided in paragraph 13-07 below.

13-07. SPOIL AREAS. - Materials to be wasted shall be deposited in the designated spoil areas shown on the drawings or in such other areas as the contracting officer may designate. The low places in the designated spoil areas shall first be filled to a uniform grade as directed by the contracting officer and additional waste material shall then be deposited uniformly over the designated area. Upon completion of wasting operations the contractor shall dress the spoil area to a uniform grade, sloping away from the roadbed with no slopes steeper than four horizontal to one vertical (4:1), all to satisfaction of the contracting officer.

13-08. BORROW AREAS.

(a) Classification. - Borrow areas for the various classes of materials are as follows:

(1) Borrow, Unclassified. - Materials for required railroad and highway embankments, in excess of materials secured from roadway excavations and other required excavations, shall be secured from borrow areas adjacent to the roadway as designated on the drawings or as directed by the contracting officer. The selection of the materials from the borrow areas and the placing of the materials in the embankments shall be subject to the approval of the contracting officer.

(2) Gravel Borrow. - Bank run gravel for surfacing the roadbed for the railroad and for the highway shall be obtained from sources approved by the contracting officer. The general requirements and information in paragraph 1-16 shall apply to gravel for roadbeds.

(b) Slopes and Berms of Borrow Pits. - Side slopes of borrow pits will usually be four horizontal to one vertical (4:1). An undisturbed berm of not less than 25 feet shall be left between the toe of the slope of embankments and the edges of the borrow pits. An undisturbed berm of not less than 10 feet shall be left between the top of the outside slope of the borrow pit and the right-of-way line.

(c) Staking of Borrow Pits. - Excavation in borrow pits shall be performed so as to leave as uniform a section as practicable in order to permit ready and accurate measurement. The depth of excavation in borrow pits shall be as directed by the contracting officer and will be dependent upon the suitability of the materials encountered in each specific location.

(d) Drainage and Final Dressing of Borrow Pits. - Borrow pits shall be excavated to a uniform grade and properly sloped and ditched so as to drain to the edge away from the roadway and to the nearest water course. The slopes of borrow pits shall be carefully dressed to the required slope and the bottom dressed to a uniform grade.

13-09. DITCHES. - Ditches shall be excavated on the uphill side and above all excavations where the original ground slopes toward the roadway, and elsewhere as indicated on the drawings or ordered by the contracting officer. Intercepting ditches shall also be constructed at the foot of all embankments where deemed necessary and to the waterway which is provided to take the drainage under the roadway. Where directed by the contracting officer intercepting ditches shall be excavated in advance of roadway excavation and embankment placing. Materials excavated from intercepting ditches shall be placed on the down hill side of the ditch and shall be neatly formed and sloped to an embankment section as directed by the contracting officer.

13-10. RAILROAD AND HIGHWAY FILLS

(a) Materials. - Materials for the construction of embankments shall be secured from excavation for the roadway, or other required excavations, or from the borrow pits. Where there is a choice of materials excavated, materials best suited for the construction of the embankment section shall be used as determined by the contracting officer.

(b) Construction of Earth Embankments. - The earth embankments shall be constructed, rolled and compacted according to the specifications for Class II compacted fill in paragraph 4-04.

(c) Superelevation on Curves. - The tops of embankments railroads constructed on curved alignment shall be elevated as shown on the drawings.

Highway widening and superelevation shall be as indicated on the drawings.

13-11. GRAVEL FILL BASE. - The gravel material shall be selected from the borrow pits within the areas the contracting officer shall direct, in order to secure the best materials available. The gravel materials shall be loaded into the hauling equipment through a 4-inch "grizzly" to remove all large stones. Gravel containing an excess of earth, sand or other unsuitable materials, as determined by the contracting officer, shall not be used. Embankments shall be constructed to final dimensions and grades free from ruts and depressions prior to the placing of the gravel. Placing and compaction of the gravel base shall be done in accordance with the specifications of the State of New York, Division of Highways, Item 39 - Foundation Course - Run of Bank Gravel.

13-12. FINISHING ROADWAY AND SLOPES. - Before requesting the contracting officer to accept any section of the roadway the contractor shall go over the entire section and shall replace materials washed or eroded from embankment slopes; trim and clean all excavation slopes; clean and dress side ditches, and fill up all wheel tracks or other depressions on the sub-grade. Materials obtained from dressing slopes and cleaning side ditches shall be removed from the limits of the excavation and disposed of as directed. The contractor will not receive extra compensation for dressing the slopes, repairing embankments and finishing sub-grade, and the cost thereof shall be included in the contract unit price for "Fill; R. R. and Highway".

13-13. MEASUREMENT. - A survey of the site area will be made just prior to the beginning of the work and all measurements will be based on this survey, without regard to any changes in the area that may occur during the prosecution of the work. Measurements will be made between the original ground surface, as determined by the above-mentioned survey and excavation of fill slope lines as shown on the drawings.

13-14. PAYMENTS.

(a) All materials excavated for the permanent railroad and highway, parking areas, ditches, road changes, and signal bases will be paid for at the contract unit price per cubic yard for "Excavation; Railroad and Highway."

(b) All materials except gravel fill base (paragraph 13-11) and topsoil for seeding (paragraph 13-23) placed in fills for the permanent railroad and highway, parking areas, and road changes, whether obtained from necessary excavation or from borrow, will be paid for at the contract unit price per cubic yard for "Fill; Railroad and Highway."

(c) No separate payment will be made for excavation from borrow pits to complete fills but shall be included in the contract unit price for "Fill; Railroad and Highway."

(d) Bank run gravel secured from gravel borrow pits and used for gravel fill base will be paid for at the contract unit price per cubic yard for "Gravel."

13-15. CULVERTS.

(a) Work Included. - The contractor shall furnish, all materials. labor, and equipment required for installing 24-inch and/or 36-inch corrugated iron drainage culverts meeting the requirements of Federal Specification QQ-C-806, as indicated on the drawings. The lengths of culverts indicated on

the drawings are approximate only, and before ordering the pipe the contractor shall secure from the contracting officer the exact lengths required at each location.

13-16. PAYMENT FOR CULVERTS. - Payment for furnishing and placing all culverts for both the railroad and highway will be made at the contract unit price per lineal foot for, "Culverts," 24-inch or 36-inch respectively.

13-17. BALLAST FOR RAILROAD.

(a) Materials. - Crushed rock for ballast shall conform to the latest A. R. E. A. "Specifications for Stone Ballast". Under quality requirements of this specification the test limits under "Suggested Specification Limits" shall conform to the requirements of Classification C.

(b) Ballasting and Surfacing. - The Contractor shall furnish and spread ballast of the kind and quality specified, raise, line, surface and tamp the track to stakes set by the contracting officer, and finish the ballast surfaces accurately to the detailed section shown on the drawings to the satisfaction of the contracting officer.

(c) Measurement and Payment. - Ballast material accepted and placed as a part of this work will be measured in cubic yards in place within the section as shown on the Plans, and no payment will be made for additional quantities required to provide for shrinkage and settlement into the roadbed, superelevation of outer rail on curves, for hand-car rests, road approaches and crossings, handcar houses, etc. Volume of ties lying within the ballast sections shall be deducted using nominal 7"x9" dimensions in computing quantities of ballast. Payment for furnishing ballast material so measured will be made at the contract unit price per cubic yard bid for "Ballast." This payment shall constitute full compensation to the Contractor for all expense necessary to furnish and transport ballast material to the work and placing in full conformity with the Plans and Specifications.

13-18. TIES.

(a) Physical Requirements. - Cross ties shall be sawed or hewed ties, 8 feet long, and shall conform to Federal Specifications MM-T-371 dated May 26, 1937, for "Ties, Wood; Cross and Switch," size No. 5, 7 inches thick by 9 inches wide on top. All ties shall be creosote treated in conformity with the latest Federal specifications. Switch ties shall conform to the quality of the above specifications, and their lengths will be as shown on the plans. Payment for switch ties will be included in payment for cross ties.

(b) Placing. - All main track shall be laid with 18 cross ties per 33 foot rail, side tracks with 16 cross ties per 33 foot rail, A proportionate number of ties shall be laid under shorter rail sections.

(c) Measurement and Payment. - Measurement for ties will be per cross tie, and payment for furnishing and installing will be made at the contract unit price each for "Cross Ties", and shall include all treatment and expense necessary to furnish and place ties in accordance with the plans and specifications.

13-19. TRACK.

(a) Materials. - The government will furnish the rails, turnouts and appurtenances which are required (See paragraph 1-10).

(b) Laying. -

(1) Rails shall be spiked with four spikes per tie on tangent

track and spikes staggered in each tie plate. On curved track two additional spikes per tie will be required unless otherwise directed by the contracting officer and these extra spikes must be placed on the inside of each rail. Spikes must be started vertically and squarely in spike hole of the tie plate and driven straight to full bearing on the base of rail. Where spikes are withdrawn the hole must be plugged, using a standard tie plug, at the Contractor's expense.

(2) Tracks must be laid to standard gage of four feet, eight and one-half inches on tangents and on curves of six degrees or less. Gage should be widened one-sixteenth of an inch for each degree over 6 degrees to a maximum of four feet nine inches as directed in each case by the contracting officer. The alignment must be maintained on outside rail and the extra width of gage applied to the inside rail. This extra width should be uniformly decreased on the spiral from the point of the circular curve to the point of tangent, or uniformly graduated in the first rail length of a simple curve.

(3) Alignment of tracks shall conform strictly to the center line stakes and the top of rail shall conform strictly to the grade stakes. Rails must be laid with broken joints in all tracks. In main track the joints on one side must not vary more than one foot in either direction from the center of the opposite rail. Rails less than standard length shall be used for curves to bring the joints to their proper position. When laying up to the switches a combination of rails less than standard length must be used to avoid cutting if practicable.

(4) In laying rail the ends shall be properly spaced to allow for expansion as directed by the contracting officer and rails must be laid consecutively to line and gage, one at a time and fully bolted before spiking. The practice of coupling up long stretches of rail and subsequently throwing to line will not be permitted.

(5) In cutting rail, a saw or chisel should be used. Use of torch will not be permitted in cutting rails or bolt holes. All necessary new bolt holes shall be drilled.

(6) Joints must be properly put on with the full number of bolts, nuts, spring washers and nuts screwed up tight. Bolts must be gone over and retightened at short intervals until all are tight. Bolts shall be placed with nuts alternately on the inside and outside of rails. Spikes should not be driven in the joint bar slots or at the ends of joint bars where the spikes may interfere with free movement of the rails.

(7) When laying rails, care must be taken to avoid locating joints in road crossings, in handcar set-offs or on ends of bridges or trestles.

(c) Measurement and Payment for Track Laying. -

(1) Measurement of track laying will be in track feet. Measurement on main track will be made along the centerline of same from point of beginning to point of ending of main track, exclusive of the concrete portion of the dam.

(2) Payment for track laying so measured will be made at the contract unit price per track foot for "Track Laying." This payment shall include the cost of all plant, equipment, tools, labor and incidental expense necessary to move track material from point of receipt to point of use; to install track, turnout, and appurtenant items in the work; to raise, line, surface and tamp all track and track appurtenances; and to do all other work necessary to complete the track work in a workmanlike manner and in full conformity with the Plans and Specifications.

13-20. SIGNS AND MARKERS. - All necessary signs and markers shown on the

drawings or required by the contracting officer shall be installed conforming to the standards of the New York Central Railroad. Payment for all signs and markers shall be included in the contract unit price for "Track Laying."

13-21. BITUMINOUS MACADAM ROAD SURFACING.

(a) General. - On top of the 9 inch gravel base, paragraph 13-11, the bottom course of the roadway surfacing shall be a 4 inch bituminous macadam penetration course, and the top course 2 inches plant mix bituminous macadam.

(b) Bottom course. - The bottom course bituminous macadam shall be 4 inches thick after compaction and rolling. The materials, methods of work, surface testing, and other items shall conform to the specifications of the State of New York, Division of Highways, Item 45-S- Bottom Course Bituminous Macadam - Penetration Method. The asphalt shall conform to Item 64P-A and the amount used shall be two gallons per square yard or as ordered by the contracting officer.

(c) Top Course. - The top course bituminous macadam shall be 2 inches thick after compaction and rolling. The materials, method of work, surface testing, and other items shall conform to the specifications of the State of New York, Division of Highways, Item 53 - Top Course Bituminous Macadam - Mixing Method, Type 3.

(d) Payment.- Payment for the bottom and top course of road surfacing will be made at the contract unit price per square yard for "Road Surfacing" which payment shall include all materials, plant, and labor necessary for completion of the roadway in accordance with the drawings.

13-22. HIGHWAY GUARD RAIL.

(a) General. - A two wire guard rail shall be installed on both sides of all embankments greater than 5 feet in height and elsewhere as directed by the contracting officer. Posts shall be 8-inch diameter fir, sound and free from defects. All posts shall be pressure creosote treated for the full length in accordance with the requirements of Federal Specification TT-W-571a for "Wood-Preservative; Preservative-treatment" as shown in Table I for empty-cell treatment of structural timber for the size and material indicated. Creosote shall conform to Federal Specification TT-W-566. All holes shall be drilled before creosoting. Wire rope shall conform to Federal Specification RR-R-571, amendment 4, dated January 1941, for "Rope, Wire," for Type III, 3 by 7, annealed steel, galvanized wire rope. Anchor rods, clamp bolts, and all metal parts and fittings shall be galvanized iron. The posts shall be set plumb, evenly spaced, and true to lines and grades as indicated on the drawings. The wire shall be put through hook bolts or through posts as required, and shall be drawn taut and fastened securely on both ends as indicated. Where necessary, cable shall be neatly and carefully spliced or joined by means of metal sockets into which the cable's ends are securely fastened by pouring full of molten zinc. Deadman type anchors shall be provided at the ends, and at intervals of 600 feet as indicated on the drawings.

(b) Payment. - Payment for furnishing and installing of guard rail, complete, will be made at the contract unit price per lineal foot for "Highway Guard Rail." Measurement will be made from center to center of end posts plus an allowance of 15 feet for each anchorage.

13-23. SEEDING.

(a) General. - The contracting officer may require that certain slopes

or other areas adjacent to the highway and railroad be prepared and seeded, either with or without the application of topsoil. If so required, the work shall conform to the specifications of paragraph 4-08.

(b) Payment. - Payment for preparing and seeding such areas will be made at the applicable contract unit price per acre for "Seeding" or for "Seeded Topsoil," which unit price shall include furnishing and applying the topsoil, fertilizer, seeds, water for sprinkling, preparation of the surface, and all other work in connection therewith.

SECTION XIV - MISCELLANEOUS ITEM AND EQUIPMENT

14-01. PIPE HANDRAILING.

(a) General. - Handrailing with required and necessary fittings shall be furnished and installed in the pier houses, on the service bridge, on the training walls and at other places as designated on the drawings or as directed by the contracting officer. All handrailing shall be of standard weight black steel pipe conforming to the requirements of paragraph 9-21 of these specifications and dimensioned and supported as shown on the drawings. The fittings shall be of malleable iron, ball pattern, with screwed or riveted-pin slip joints as shown and shall conform to the requirements of paragraph 9-21.

(b) Payment. - Payment for furnishing and installing handrailing, will be made at the contract unit price per linear foot for "Handrailing; Steel Pipe" for the size and type required. Measurement for payment will be made along the top rail between centers of supports. The contract price shall include all fittings, embedded supports, expansion and anchor bolts necessary for installation, and painting as specified in Section X.

14-02. DOORS.

(a) General. - Steel doors and frames shall be furnished and installed in the compartments of the north and south bulkheads as shown on the drawings. The doors and frames shall conform to the requirements of paragraph 11-06.

(b) Payment. - Payment for furnishing and installing steel doors and frames, complete with hardware, will be made at the contract unit price per pound for "Doors and Windows; Steel."

14-03. SAFETY TREADS.

(a) General.- Safety treads shall be furnished and installed by the contractor in all concrete stairs as shown on the drawings. Safety treads shall conform to the requirements of paragraph 9-03.

(b) Payment. - Payment for furnishing and installing safety treads complete with anchorages will be made at the contract unit price per pound for "Safety Treads."

14-04. BUBBLER PIPES.

(a) General. - Each spillway section shall be provided with 3 bubbler pipes complete with nozzles and malleable iron pipe caps and installed as indicated on the drawings. Care shall be taken during handling and installation to insure that the tubes are not bent or deformed and are free from burrs and foreign matter.

(b) Tubes. - Bubbler pipes shall be 3/4-inch brass pipe conforming to Federal Specification WW-P-351 and Errata 1 dated October 1930 for "Pipe; Brass, Seamless; Iron-Pipe-Size, Standard and Extra Strong," Grade A.

(c) Nozzles.- Bubbler pipe nozzles shall be of stainless steel conforming to Federal Specification QQ-S-763 for "Steel, Corrosion-Resisting; Bars and Forgings," Grade 6, and shall be installed as shown on the drawings or as directed by the contracting officer.

(d) Payment. - Payment for furnishing and installing bubbler pipes,

complete with nozzles and pipe caps will be made at the contract unit price each for "Bubbler Pipes."

14-05. ELECTRICAL CONDUIT SYSTEM.

(a) General. - Only that portion of the electrical conduit system which will be embedded in concrete or as may be directed by the contracting officer will be installed under this contract. This will include conduit for roadway lighting, branches to heaters, flood lights and crane circuits, and embedded feeders.

(b) Workmanship. - Rigid metal conduit shall be installed in accordance with the requirements of the National Electric Code and to the satisfaction of the contracting officer. Ends of metal conduit shall be reamed to remove rough edges and burrs and all joints between lengths of conduit, and at switches, junction boxes and fittings shall be watertight and shall provide electrical continuity of the conduit run so that it can be effectively grounded. Open conduit ends shall be capped, except when working on the run, to exclude dirt and moisture. Conduit runs shall be pitched to provide suitable drainage and all low sections of conduit runs that may trap water shall be vented for drainage in a suitable manner. Any run of conduit extending through a construction joint, or changing from an embedded to an open run, shall extend not less than the threaded length plus 1 inch past the face of the concrete. All conduit bends shall have a radius not less than that recomended by the National Electric Code. Field bends may be used if of the proper radius and carefully made with suitable tools so that the conduit is not flattened. No threadless fittihgs or running thread couplings shall be used in conduit runs. All conduit terminations shall be threaded and sealed with pipe caps, couplings and pipe plugs or conduit bushings and metal discs, before concreting operations are commenced.

(c) Expansion Joints. - Where conduit runs cross structural expansion joints, of standard manufacture similar or equal to Crouse-Hinds Type XJ Condulets shall be provided. Grounding jumpers shall also be provided to insure electrical continuity in accordance with the National Electric Code.

(d) Conduit. - All conduit shall be rigid metal conduit, enameled on the inside and outside and shall conform to Federal Specification WW-G-571, dated June 6, 1933, for "Conduit; Steel, Rigid, Enameled."

(e) Conduit Fittings. - All conduit fittings shall be high test gray iron or malleable iron castings, enameled on the inside and ouside, of the types and sizes specified or indicated. They shall be approved by the National Board of Fire Underwriters.

(f) Payment. - Payment for furnishing and installing metal conduit, including conduit fittings and supports, completely installed in place, will be made at the contract unit price per pound for "Conduit; Metal."

14-06. ELECTRICAL GROUNDING SYSTEM.

(a) General. - An electrical grounding system shall be furnished and installed as shown on the drawings, for the protection of all machinery and equipment on the dam. Five ground cables shall be embedded in the concrete of the dam where directed, with 100 ft. of each cable resting on the river bed, and the upper end exposed for connection to the longitudinal cables. Each embedded cable shall be of sufficient length for the complete installation and the unattached part shall be temporarily coiled and protected. No splices shall be made in any embedded ground cable.

Two exposed cables shall extend the full length of the dam and

shall be supported at intervals of 10 ft. or less. Each of these longitudinal cables shall be connected to all five of the embedded ground cables in an approved manner.

(b) Cable. - Ground cable shall be standard bare stranded annealed copper, single conductor cable. The size shall be as shown on the drawings.

(c) Payment. - Payment for furnishing and installing the grounding system in place as required, including all necessary conduit nipples, bushings and protective housings, will be made at the contract lump sum price for "Electrical Grounding System."

14-07. FLOOR GRATING.

(a) General. - Floor grating shall be furnished and inatalled for the drainage gutters in the service and inspection galleries as shown on the drawings.

Floor gratings shall conform to Federal Specification RR-G-661a for "Gratings; Steel, Floor (Except for Naval Vessels)," Type I, welded cross members and 1" x 3/16" bearing bars.

(b) Payment. - Payment for furnishing and installing floor gratings, accurately fitted, and painted as required will be made at the contract unit price per pound for "Floor Grating; Steel."

14-08. HATCH COVERS.

(a) General. - Hatch covers shall be provided for the hatch openings of the gate repair and storage chambers in the north bulkhead section. The hatch covers shall be constructed of reinforced class "A" concrete and structural steel as detailed on the drawings.

(b) Payment. - Payment for constructing, installing and painting the hatch covers will be made at the respective contract unit prices for "Concrete; class "A" "Steel Erection; Concrete Reinforcing" and "Steel Erection; Structural."

14-09. GALLERY GUTTER DRAINS.

(a) General. -Cast iron pipe drains, located as shown on the drawings shall be installed between the porous concrete drains and the service and inspection gallery gutters. Cast iron pipe for the drains shall conform to Federal Specification WW-P-401 for "Pipe and Pipe-Fittings; Soil, Cast-Iron."

(b) Payment.- Payment for furnishing and installing cast-iron gallery gutter drains will be made at the contract unit price per pound for "Pipe; Cast-Iron."

14-10. GALLERY AND PUMP SUMP DRAINS.

(a) General. - Steel pipe drains complete with check valves shall be furnished and installed in the inspection gallery and pump sumps; as shown on the drawings. The pipe shall be straight, free from rust, oil, and foreign matter and shall be plugged during concreting operations. Joints in the steel pipe drains shall be welded.

(b) Pipe. - Pipe shall conform to Federal Specification WW-P-403a for "Pipe; Steel and Ferrous-Alloy, Wrought, Iron-Pipe-Size," Type I Class "A", black.

(c) Valves. - Each drain shall be provided with a 10" check valve, horizontal swing type, balanced gate, iron body, bronze mounted, similar and equal to the valve shown in Figure 186-a, page 46, 1940 catalog of the Eddy

Valve Company, Waterford, N.Y.

(d) Payment. - Payment for furnishing and installing gallery and pump sump steel pipe drains, complete with check valves, will be made at the contract unit price each for "Gallery Drains."

14-11. BRONZE STAGE GAUGES.

(a) General. - Bronze stage gauges consisting of cast bronze numerals and markers shall be furnished and installed on each bulkhead as shown on the drawings. The bronze shall conform to the requirements of paragraph 9-10. The numerals and markers shall be of the type and size and contain anchors essentially as shown on the drawihgs, except that commercial numerals may be furnished subject to the approval of the contracting officer. The numerals and markers shall be installed in such a manner that the face of the metal is flush with the face of the concrete and shall be accurately placed on the form and securely attached thereto, by any method the contractor may elect, subject to the approval of the contracting officer. The numerals and markers shall not be displaced during concreting operations. After removal of the forms, the contractor shall polish the faces of the numerals and markers and smooth finish the concrete adjacent to the metal.

(b) Payment.- Payment for furnishing, installing and polishing bronze stage gauges will be made at the contract unit price per pound for "Bronze; Castings."

14-12. AIR VENT GRILLS AND SUMP PUMP SUPPORTS.

(a) General. - The air vents at each end of the service and inspection galleries shall be provided with strutural steel grills, complete with copper wire mesh screens and anchor bolts, fabricated and installed as shown on the drawings. Structural steel sump pump supports shall be furnished and installed as shown on the drawings. Structural steel shall conform to the requirements of paragraph 9-04.

(b) Payment. - Payment for furnishing, installing and painting pump sump supports and air vent grills complete with copper screens and anchor bolts will be made at the contract unit price per pound for "Steel; Structural, Miscellaneous."

14-13. BALCONY RAILING.

(a) General. - The balconies of the pier houses shall be provided with structural steel railing, fabricated and installed as shown on the drawings. Structural steel shall conform to the requirements of paragraph 9-04.

(b) Payment. - Payment for furnishing, installing and painting balcony railing, complete with anchor bolts, will be made at the contract unit price per pound for "Steel; Structural, Miscellaneous."

14-14. GUARD CHAINS & MISCELLANEOUS BOLTS & FORGINGS.

(a) General. - Forged steel guard chains complete with anchors and hooks as described in paragraph 9-28 shall be provided and installed at pier stairways, pump sump manholes and other locations. Miscellaneous bolts and forgings shall be furnished and installed as shown on the drawings or as may be required by the contracting officer.

(b) Payment. - Payment for furnishing and installation of guard chains, guard chain hooks and anchors, and miscellaneous bolts and forgings

for which payment is not otherwise provided will be made at the contract unit price per pound for "Steel Forgings; Miscellaneous."

14-15. BRAZING, FIELD RIVETING, AND FIELD WELDING.

(a) Brazing. - The surfaces at the joint shall first be thoroughly cleaned and the parts firmly clamped together. The brazing shall be done in such a way as to prevent oxidation during the process, preferably by using a calcined flux. The spelter shall be a copper-zinc alloy composed of 64% copper and 36% zinc.

(b) Field Riveting. - The rivet sizes shown on the drawings are the actual size of the cold rivets before heating. All connections shall be accurately and securely fitted up before the rivets are driven. Drifting done during assembling shall be only such as to bring the parts into position and not sufficient to enlarge the holes or distort the metal. Rivets shall be driven with a pneumatic hammer and a pneumatic bucker used where practicable. Rivets shall be heated uniformly to a light cherry-red color and driven while hot. They shall not be burned or over-heated. When heated and ready for driving they shall be free from slag, scale and other adhering matter. When driven they shall completely fill the holes. Heads shall be of an approved shape, of full and equal sizes, free from fins, concentric with the shanks, shall have full contact with the surface of the member, and shall grip the assembled parts firmly together. Unless otherwise specified or authorized, counter-sunk rivets shall be chipped or ground flush. Loose, burned, badly formed, or otherwise defective rivets shall be replaced. In removing defective rivets care shall be taken not to injure the adjacent metal and, if necessary, they shall be drilled out. Calking or recupping of defective rivets will not be permitted. In any case when a cold rivet of the size specified cannot be entered with light tapping, the hole shall be reamed with a twist reamer.

(c) Field Welding. - Welding will be permitted only where specifically called for on the drawings or as authorized by the contracting officer. All pieces to be welded shall be free from rust, paint, or other foreign matter for a distance of not less than 1/2 inch back from the welding edge.

All welding shall be done by competant welders by the electric arc method, using a process which will exclude the atmosphere from the molten metal. The welding shall be done in a manner that will produce complete fusion with the parent metal. Unless otherwise specified, the applicable current codes, specifications and recomended practices of the American Welding Society shall govern all welding work. Certification of welders will not be required unless, in the opinion of the contracting officer, inspection of the work indicates that unsatisfactory welds are being produced.

Field welding on gates will, in general, be only for the purpose of calking joints or plugging holes. However, welding may be required or allowed by the contracting officer for certain other minor details.

Deposited weld metal shall have corrosion, physical and chemical characteristics consistent with those of the base metal. Coated welding rods, if used, shall be of the heavily coated type.

14-16. PLUMBING.

(a) General. - The necessary embedded pipe and connections for the future plumbing system shall be furnished and installed as shown on the drawings. Joints in bell and spigot pipe shall be made with caulking jute and sulphur-base joint compound approved by the contracting officer. Joints in

steel or wrought iron pipe shall be threaded. Open ends of pipe shall be capped or otherwise protected to prevent clogging of the pipe or damage to the ends.

(b) Payment. - Payment for furnishing and installing plumbing under this contract will be made at the applicable contract unit price per pound for "Pipe; Cast Iron," "Pipe; Wrought Iron," or "Pipe; Black Steel, Miscellaneous," which payment shall include the cost of furnishing joint material and making pipe connections as required.

14-17. DECK DRAINS.

(a) General. - Drains consisting of cast iron frames and gratings shall be installed in the deck of the bulkheads as shown on the drawings. The drains shall be connected to wrought iron or cast iron pipe as shown on the drawings. Joints in bell and spigot cast iron pipe shall be made with caulking jute and sulphur-base joint compound approved by the contracting officer.

(b) Payment. - Payment for furnishing and installing deck drains and piping will be made at the applicable contract unit price for "Iron; Cast," "Pipe; Cast Iron," or "Pipe; Wrought Iron," which payment shall include the cost of furnishing joint material and making pipe connections as required.

14-18. PARKING AREAS.

(a) General. - Parking areas shall be constructed where shown on the drawings. The areas shall be graded to 6 inches below the finished grade as established by the contracting officer and compacted similar to Class I fill of the embankments. The areas shall be covered with selected bank run gravel similar to the sand and gravel backing specified in paragraph 4-06 (b) to provide a depth not less than 6 inches after compaction. The gravel surfacing shall be rolled to provide a smooth, firm surface, with a slope to provide a good surface drainage.

(b) Payment. - Payment for grading will be made at the contract unit prices per cubic yard for "Excavation; R.R. and Highway" and "Fill; R.R. and Highway." Payment for gravel surfacing will be made at the contract unit price per square yard for "Rolled Gravel Surface," which payment shall include furnishing and placing as required.

14-19. FLAGSTONE STEPS.

(a) General. - Flagstone steps shall be constructed as shown on the drawings. The stones shall be selected from the required rock excavation for the dam. The stones shall be laid over a sub-base of selected bank run gravel and bedded in portland cement mortar of approved mix. All work shall be done in accordance with best standard practice.

(b) Payment. -Payment for furnishing and placing flagstone steps will be made at the contract unit price per square yard for "Flagstone Steps."

14-20. STONE WALL.

(a) General. - Stone walls laid in mortar of approved mix shall be constructed as shown on the drawings. The walls shall be true to line and constructed in accordance with the best standard practice.

(b) Payment. - Payment for furnishing and constructing the stone wall will be made at the contract unit price per cubic yard for "Stone Wall."

Long Sault Dam

Invitation No.

STANDARD COVERNMENT FORM OF BID
(Construction Contract)

_____

(Place) _____

(Date) _____

To: The District Engineer,
U. S. Engineer Offece,
Massena, New York.

1. In compliance with your invitation for bids dated _____ _____ and subject to all the conditions thereof, the undersigned, _____, a corporation organized and existing under the laws of the State of _____, a partnership consisting of _____ _____ _____ or an individual trading as _____ _____ of the city of _____ hereby proposes to furnish all plant, labor, and materials and perform all work required for the construction of the long Sault Dam, complete, at the locations shown and to the extent indicated, in strict accordance with the specifications, schedules, and drawings, for the consideration of the following prices:

SCHEDULE OF BID ITEMS

Item No.	Designation	Unit	Quantity	Unit Price	Amount
1	Excavation; Crib Footing	Cu.Yd.	65,900	$_____	$_____
2	Timber Cribs	M.B.M.	5,200	$_____	$_____
3	Crib Sheathing (Bulkhead)	Sq.Ft.	13,800	$_____	$_____
4	Steel Sheet Piling	Sq.Ft.	44,200	$_____	$_____
5	Crib Fill	Cu.Yd.	118,200	$_____	$_____
6	Earth Fill; Cofferdams	Cu.Yd.	310,000	$_____	$_____
7	Rock Fill; Cofferdams	Cu. Yd.	26,500	$_____	$_____
8	Riprap; Cofferdams	Cu.Yd.	15,700	$_____	$_____
9	Derrick Stone; Cofferdams	Ton	5,000	$_____	$_____
10	Cofferdam Removal	Cu.Yd.	376,800	$_____	$_____
11	Unwatering Cofferdams	AcreFt.	56,000	$_____	$_____
12	Excavation; Diversion Cuts; Earth	Cu.Yd.	3,310,000	$_____	$_____
13	Excavation; Diversion Cuts; Rock	Cu.Yd	5,000	$_____	$_____
14	Fill; Massena Weir, Rock	Cu.Yd	6,500	$_____	$_____
15	Excavation; Massena Weir	Cu.Yd.	35,000	$_____	$_____
16	Stop logs; concrete	Cu.Yd.	1,180	$_____	$_____
17	Diversion Gates; Operation and Maintenance	Sum	Job	$_____	$_____
18	Excavation; Common	Cu.Yd	490,000	$_____	$_____
19	Excavation; Rock	Cu.Yd	80,000	$_____	$_____
20	Excavation; Borrow	Cu.Yd.	180,000	$_____	$_____
21	Line Drilling	Sq.Ft.	45,000	$_____	$_____
22	Drilling 3-inch Exploratory holes	Lin.Ft.	17,400	$_____	$_____

SCHEDULE (Continued)

Item No.	Designation	Unit	Quantity	Unit Price	Amount
23	Drilling 6-inch Holes	Lin.Ft.	7,500	$_____	$_____
24	Drilling 6-inch Concrete Cores	Lin.Ft.	1,000	$_____	$_____
25	Drilling Foundation Grout Holes in Rock	Lin.Ft.	64,000	$_____	$_____
26	Drilling Foundation Grout Holes in Concrete	Lin.Ft.	5,000	$_____	$_____
27	Pressure Grouting	Cu.Ft.	40,000	$_____	$_____
28	Core Boxes	Each	930	$_____	$_____
29	Excavation, Railroad And Highway	Cu.Yd.	130,000	$_____	$_____
30	Fill;Railroad and Highway	CuYd.	175,000	$_____	$_____
31	Earth Fill;Compacted	Cu.Yd	280,000	$_____	$_____
32	Additional compaction	Square (100sf)	100,000	$_____	$_____
33	Filter	Cu.Yd.	16,700	$_____	$_____
34	Riprap, Dumped; ClassA	Cu.Yd.	12,400	$_____	$_____
35	Riprap,Dumped; ClassB	Cu.Yd.	22,400	$_____	$_____
36	Sand and Gravel Backing	Cu.Yd.	6,600	$_____	$_____
37	Road Surfacing	Sq.Yd	66,000	$_____	$_____
38	Seeded Top Soil	Acre	6	$_____	$_____
39	Seeding	Acre	4	$_____	$_____
40	Concrete; Class A	Cu.Yd.	17,500	$_____	$_____
41	Concrete; Class B	Cu.Yd	41,000	$_____	$_____
42	Concrete;ClassC	Cu.Yd	525,000	$_____	$_____
43	Rock Flour in Grout	Cu. Ft.	2,000	$_____	$_____
44	Sand in Grout	Cu.Ft.	2,000	$_____	$_____
45	Drains; Porous Concrete	Lin.Ft.	31,300	$_____	$_____

SCHEDULE (Continued)

Item No.	Designation	Unit	Quantity	Unit Price	Amount
46	Special Bituminous Filler; Type C	Cu.Ft.	1,700	$_____	$_____
47	Steel Erection; Structural	Lbs.	7,500,000	$_____	$_____
48	Steel Erection; Concrete Reinforcing	Lbs.	5,000,000	$_____	$_____
49	Steel Rails; placing	Lbs.	781,000	$_____	$_____
50	Spillway Gates; Erection	Lbs.	14,605,000	$_____	$_____
51	Gantry Cranes and Fixed Hoists; Erection	Sum	Job	$_____	$_____
52	Steel Forgings; Miscellaneous	Lbs.	2,500	$_____	$_____
53	Steel; Structural, Miscellaneous	Lbs.	5,000	$_____	$_____
54	Iron; Cast	Lbs.	40,000	$_____	$_____
55	Pipe; Cast Iron	Lbs.	38,000	$_____	$_____
56	Pipe; Wrought Iron	Lbs.	37,000	$_____	$_____
57	Pipe; Black Steel, 8 in.	Lbs.	65,300	$_____	$_____
58	Pipe; Black Steel, Miscellaneous	Lbs.	2,000	$_____	$_____
59	Pipe; Concrete, Halved	Lin.Ft	5,600	$_____	$_____
60	Culverts 24 in.	Lin.Ft	575	$_____	$_____
61	Culverts 36 in.	Lin.Ft.	600	$_____	$_____
62	Babbitt	Lbs	46,000	$_____	$_____
63	Bronze; Castings	Lbs	3,400	$_____	$_____
64	Copper; Sheet	Lbs	930	$_____	$_____
65	Corrugated Iron; Water stops	Lbs	73,000	$_____	$_____
66	Doors & Windows; Steel	Lbs	4,600	$_____	$_____
67	Highway Guard Rail	Lin.Ft.	29,000	$_____	$_____
68	Handrailing; Steel Pipe, 2 in.	Lin.Ft.	6,300	$_____	$_____
69	Handrailing; steel pipe, 1- 1/2" in.	Lin.Ft.	600	$_____	$_____

SCHEDULE (Continued)

Item No.	Designation	Unit	Quantity	Unit Price	Amount
70	Floor Grating: Steel	Lbs.	55,000	$_____	$_____
71	Safety Treads	Lbs.	8,300	$_____	$_____
72	Scuttles	Each	2	$_____	$_____
73	Roof Ventilators	Each	6	$_____	$_____
74	Flagpole	Each	6	$_____	$_____
75	Glass Brick	Sq.Ft.	440	$_____	$_____
76	Conduit; Metal	Lbs.	30,000	$_____	$_____
77	Electrical Grounding System	Sum	Job	$_____	$_____
78	Bubbler Pipes	Each	120	$_____	$_____
79	Gallery Drains	Each	9	$_____	$_____
80	Roof Drains	Each	6	$_____	$_____
81	Roof Surfacing	Square (100sf)	8	$_____	$_____
82	Rolled Gravel Surface	Sq.Yd.	15,300	$_____	$_____
83	Flagstone Steps	Sq.Yd	50	$_____	$_____
84	Stone Wall	Cu.Yd	120	$_____	$_____
85	Gravel	Cu.Yd	35,000	$_____	$_____
86	Ballast	Cu.Yd	11,700	$_____	$_____
87	Gross Ties	Each	11,000	$_____	$_____
88	Track Laying	Track Ft.	19,600	$_____	$_____
89	Field Office	Sum	Job	$_____	$_____
90	Field Office Extension	Sum	Job	$_____	$_____

NOTES: (a) All amounts and totals given above will be subject to verification by the United States. In case of variation between unit bid price and totals shown by bidder, the unit price will be considered to be his bid.

(b) All bids must be for the entire work and must have each blank space filled in.

(c) The quantities of each item of the bid, as finally ascertained at the close of the contract, in the units given and the unit prices of the several items stated by the bidder in the accepted bid, will determine the total payments to accrue under the contract. The unit price bid for each item must allow for all collateral or indirect cost connected with it.

2. EXPERIENCE. (See Invitation for Bids, paragraph 16.)

3. STATEMENT ESTABLISHING PERMANENT PLACE OF BUSINESS AND FINANCIAL STATUS. (See Invitation for Bids.)

STATEMENT ESTABLISHING PERMANENT PLACE OF BUSINESS AND FINANCIAL STATUS. (Continued)
(See Invitation for Bids.)

4. PLANT TO BE USED ON THE WORK. (See Invitation for Bids and paragraph 1-20 of the specifications.)

(a) Earthwork.

(1) Excavating Equipment.

No.	Type	Manufacturer	Capacity	Age	Condition

(2) Transporting Equipment.

(3) Embankment Equipment.

(a) Spreading and Rolling Equipment.

(3) Embankment Equipment. (Continued)

(a) Spreading and Rolling Equipment.

No.	Type	Manufacturer	Capacity	Age	Condition

(b) Pumping and Watering Equipment.

(b) Concrete.

(1) Batching Equipment.

(2) Transporting Equipment.

(3) Miscellaneous Equipment.

No.	Type	Manufacturer	Capacity	Age	Condition

(c) Drilling Equipment.

(d) Grouting Equipment.

(e) Compressed Air Equipment.

No.	Type	Manufacturer	Capacity	Age	Condition

(f) Pumping Equipment.

(g) Miscellaneous Equipment.

5. PLANT LAY-OUT (See Invitation for Bids). - The undersigned has attached herewith the plant lay-out prescribed in the Invitation for Bids.

6. PROGRESS CHARTS (See Invitation for Bids). - The undersigned has attached herewith the progress charts prescribed in the Invitation for Bids.

7. It is hereby warranted that in the event award is made to the undersigned there will be used in the performance of the work covered by the contract only such unmanufactured articles, materials, and supplies as have been mined or produced in the United States, and only such manufactured articles, materials, and supplies as have been manufactured in the United States substantially all from articles, materials, or supplies mined, produced, or manufactured, as the case may be, in the United States except as noted below or otherwise indicated in this bid or authorized in the specifications.

8. The undersigned agrees, upon receipt of written notice of the acceptance of this bid within ____ days after the date of opening of the bids, to execute the standard form of Government contract, in accordance with the bid as accepted, and give performance and payment bonds, with good and sufficient surety or sureties, for the faithful performance of the contract, and for the protection of all persons supplying labor and materials in the prosecution of the work, within ___ days after the prescribed forms are presented for signature.

9. The undersigned agrees to begin the work within ___ calendar days after date of receipt of notice to proceed, and complete it within ____ calendar days after date of receipt of said notice to proceed.

_____
(Bidder)

By _____
(Name and Title)

_____
(Business Address)

NOTE: Read Standard Government Instructions to Bidders before preparing this bid.

PART TWO

LONG SAULT DAM

PURCHASE SPECIFICATIONS

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a. Structural Steel and Reinforcing Steel

b. Spillway Gates

c. Gantry Crane

NOTE

Due to lack of time and the present uncertainty as to final construction and shipping schedules and the final contract form desired, only the sections dealing with technical requirements for the furnishing of materials and equipment have been included in each specification. It is intended that the general provisions of the contract, in each case, will be included in Section I which has been purposely omitted.

SECTION II - REQUIREMENTS

2-01. MATERIAL REQUIRED. - The material required under this contract consists of the following items:

(a) Gate guide towers for piers No. 1 to 14 inclusive and for the spillway end of the south bulkhead.

(b) Grillages for supporting diversion gate dogs for 18 diversion openings, together with anchor bolts and pipe corings.

(c) Pier nose armor for piers No. 1 to 14 inclusive and for the spillway end of the south bulkhead.

(d) Plate girders for the entire 40 spans of the spillway, consisting of two crane girders and two highway girders for each span, together with end bearing details and anchors.

(e) Angles, plates etc. for construction and expansion joints in spillway bridge deck for 14 spans, consisting of 7 expansion joints and 8 construction joints.

(f) Anchor bolts for the railroad rails from the south end of the south bulkhead to the centerline of pier No. 14 and anchor bolts for the crane rails from the south end of the crane rails to the centerline of pier No. 14.

(g) Crane rails from the south end of the south bulkhead to the centerline of pier No. 14, including bearing plates, shims, rail clips, splice bars and bolts and other necessary appurtenances.

(h) Ladders and platforms for the sides of spillway piers from the south bulkhead to pier No. 14 inclusive, and Ladders for the south bulkhead.

(i) Service bridge to be supported from the spillway bridge from the south bulkhead to pier No. 14.

(j) Enclosure for the crane collector bars, from the south end of the collector arm travel to the centerline of pier No. 14.

(k) Miscellaneous items of structural steel including the gantry crane stops at the south bulkhead, temporary and permanent field erection bolts for all items, and other items from the south end of the dam to pier No. 14 inclusive as directed by the contracting officer.

(l) Reinforcing steel for the south bulkhead and for the spillway to and including pier monolith No. P 14.

2-02. SCHEDULE A.

Schedule A covers the furnishing of all items from (a) to (k) inclusive as specified in paragraph 2-01, and including all necessary appurtenances such as bolts, anchors,and pipe sleeves.

2-03. SCHEDULE B.

Schedule B covers the furnishing of all reinforcing steel as specified in paragraph 2-01, item (l).

2-04. COORDINATION OF DESIGNS.

The contractor shall coordinate his designs and detailed drawings with those of related structures by means of drawings or information furnished by the contracting officer. Any other information which is necessary for furnishing the required materials, and which is at present lacking in the drawings or specifications, will be furnished by the contracting officer by means of later detailed drawings or otherwise.

Holes which are to be used for connections of equipment not furnished by the contractor shall be drilled or reamed to metal template furnished by the contracting officer or made from information given by him; or drilled or reamed with parts assembled. All templates shall be and remain the property of the Government.

SECTION III - UNIT STRESSES

3-01. STRUCTURAL CARBON STEEL.

The unit stresses in structural carbon steel shall not exceed those corresponding to an 18,000 lb. per square inch base as specified in the American Institute of Steel Construction's "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" as revised January 1934.

3-02. STRUCTURAL SILICON STEEL.

The unit stresses in structural silicon steel shall not exceed those corresponding to a 24,000 lb. per square inch base.

3-03. WELDS

The unit stresses in welds shall not exceed the following:

Shear 11,300 lb. per sq. in.
Tension 13000 lb. per sq. in.
Compression (on butt Welds) 15000 lb. per sq. in.

SECTION IV -DESIGN LOADS

4-01. GATE GUIDE TOWERS.

The towers shall be designed to withstand the maximum loading conditions during construction and, after completion of the piers, to transmit the maximum loads from the track rails and from the gate dogs to the pier concrete. Each permanent gate dog grillage which is part of the tower, shall be designed to support a load of 180,000 lbs. at the dog seat and to distribute the resulting reaction from the dog casting through the bearing pad, pivot pin and supporting beams to the pier.

4-02. DIVERSION GATE DOG SUPPORT GRILLAGES.

Each diversion gate dog grillage shall be designed to support a load of 290,000 lbs. at the dog seat and to distribute the resulting reaction from the dog casting through the bearing pad, pivot pin and supporting beams to the pier.

4-03. SPILLWAY BRIDGE GIRDERS.

(a) Upstream Crane Girders. -The upstream crane girders shall be designed for the moving loads from one four-wheel crane truck with wheels spaced 3'-4'-3' on centers, in addition to the dead load of steel and concrete. The static vertical load per wheel shall be taken as 100,000 lbs. for spans 1 to 20 inclusive and 80,000 lbs. for spans 21 to 41 inclusive.

(b) Downstream Crane Girders. -The downstream crane girders shall be designed for the moving loads from one four-wheel crane truck, with wheels spaced 3'-4'-3' on centers, plus their proportion of the American Association of State Highway Officals' standard H-20 truck loading on the highway, plus the dead load of steel and concrete. The static vertical load per wheel on the cranetruck shall be taken as 66,000 lbs. for all spans.

(c) Railroad Girders. -The railroad girders shall be designed for the standard E-70 train loading, plus the dead load of steel and concrete.

(d) Impact. -The static live loads from crane and railroad on all girders shall be increased 25% for impact allowance.

(e) Camber. -All girders shall be cambered an amount equal to the maximum computed deflection due to the dead load of steel and concrete. The weight of concrete for this purpose shall be assumed as 155 pounds per cubic foot, with no allowance for minor openings.

4-04. CRANE RAILS.

The crane rails and anchors shall be designed for the maximum vertical and horizontal loads from the crane truck wheels, with the crane in static or operating condition. The horizontal loads on the rail head shall be assumed as 20% of the vertical loads.

4-05. SERVICE BRIDGE.

The service bridge shall be designed for a live load of 100 lbs. per square foot over the entire area plus a concentrated load of 500 lbs. at any point. For the design of the grating the 500 pound load shall be assumed as

distributed over one square foot.

4-06. GANTRY CRANE STOPS.

The gantry crane stops shall be designed for a horizontal load resulting from collision of the loaded gantry crane running at full speed with power off. Seventy-five percent of the total load shall be applied at each stop at the elevation of the crane bumper. In computing the horizontal load, the speed of the crane shall be assumed as reduced from full speed to zero within a distance of travel equal to the maximum movement of the bumper plunger on the crane truck.

SECTION V - STRUCTURAL DETAILS

5-01. GENERAL.

The guide towers, dog grillages, pier nose armor, plate girders, and the construction and expansion joint details shall be of structural steel shapes and plates. Shop connections shall in general be riveted or welded and field connections shall be riveted, or bolted as indicated on the drawings or as approved by the contracting officer. Webs of beams and channels shall be not less than 1/4 inch thick. All other structural material except fillers shall be not less than 3/8 inch thick. Except as otherwise specified or shown on the drawings, the design shall be in accordance with the American Institute of Steel Constructions "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" as revised in 1936. General design details of plate girders shall be in accordance with Section IV of the American Railway Engineering Association's "Specifications for Steel Railway Bridges" dated 1940.

5-02. GATE GUIDE TOWERS.

In general, construction of the guide towers shall be as shown on the Government's drawings. Particular care shall be exercised in the design that the required tolerances and clearances are maintained and that the towers may be accurately plumbed and held in true position in the field while concrete is being poured around them. Shop connections shall be welded, but the grillages for supporting the gate dogs shall be riveted. The pin plates shall be machined accurately to the required bevel and the holes reamed for a loose fit on the pin after riveting the entire grillage assembly.

5-03. DIVERSION GATE DOG SUPPORT GRILLAGE.

The grillages shall consist of rolled sections and plates held in position by anchor bolts. The pipe casings for the push rods shall be of sufficient size to allow a free movement of the push rod. The pin plates shall be riveted to the grillage beams and the pin holes shall be accurately reamed for a loose fit on the pins after riveting the entire assembly. Provision shall be made in the design to permit placing and removing the dogs and operating rods after the concrete is poured. Anchor bolts and details shall be of sufficient size to transmit the reaction at the end of the grillage to the pier concrete.

5-04. SPILLWAY BRIDGE GIRDERS.

Plate girders shall be of the single web type and shall be proportioned by the moment of inertia of the net section. All girders shall be completely shop-fabricated by riveting and shipped in one piece except for end bearings. The girders shall be cambered for dead load deflection as specified in Para. 4-03 (e).

5-05. CRANE RAILS.

The rails shall be Lorain crane rails, Section No. 175-418, and shall be furnished complete with bearing plates, anchor bolts, splice bars, clips and other necessary fittings. The rails shall be

accurately formed to the required curvature.

5-06. SERVICE BRIDGE.

The service bridge shall consist of channel stringers and channel spacers supported from the concrete of the spillway bridge by angle hangers. The floor shall be grating and the railing shall be of angles. Field connections shall be so arranged that the shipping pieces may be easily handled and erected.

5-07. GANTRY CRANE STOPS.

The crane stops shall be of structural steel framing with a steel striking plate for the crane bumper. Two permanent stops are to be placed at the south abutment of the dam, one at the south end of each rail of the crane runway. The framing shall be designed to transmit the load specified in paragraph 4-06 from the striking plate to the bulkhead concrete. It is intended that the steel framing of the permanent crane stops will be encased in concrete. Two temporary stops are to be placed near the center line of pier No. 14, one at the temporary end of each rail of the crane runway. These stops shall be removable, and suitable for future encased permanent stops at the permanent north end of the runway.

5-08. EXPANSION AND CONSTRUCTION JOINT STEEL.

Expansion joint steel shall consist of curb angles, with welded strap anchors, supporting heavy sliding cover plates with interlocking teeth on the roadway portion of the bridge and plates with beveled edges on the sidewalk portion. Construction joint steel shall consist of curb angles, with welded strap anchors, separated at the bottom by a bar welded on the angle on one side of the joint to provide a slot for filling with expansion joint material.

5-09. LADDERS AND PLATFORMS.

Ladders and platforms shall be provided at all locations shown on the drawings or required by the design. Ladders shall be not less than 14 inches wide, with one inch diameter rungs spaced 12 inches on centers between 2½ inch by 3/8 inch side bars. The rungs shall be inserted 1/4 inch in punched holes in the side bars and welded on both sides of the side bars. The ladders shall be equipped with circular safety guards of adequate design where indicated on the drawings. The platforms shall consist of steel channels with grating floor, and shall be provided with steel angle railing.

5-10. NICHE FILL ANCHORS. - These anchors shall consist of two sets of 3/4" plain round bars, threaded on one end and hooked on the other end, together with threaded couplings, one for each pair of bars. One set of bars with couplings attached are to be embedded in the pier concrete with couplings flush with the surface. Before the niche filler is placed, the second set of bars will be attached to the couplings to act as reinforcement for the niche fill concrete.

5-11. RAIL ANCHORS. - Anchors for the railroad rails shall consist of rods threaded at one end and hooked at the other end for embedment in the concrete. A bearing plate for the rail shall be provided for each pair of bolts. Details of the anchors shall be suitable for use with a rail of a weight not less than 90 pounds per yard. Information as to the

exact size of rail will be furnished by the contracting officer.

5-12. COLLECTOR BARS ENCLOSURE. - The enclosure for the collector bars shall consist of plates and angles welded together, welded-on strap anchors, and a removable steel plate cover attached with bronze screws. Provision shall be made for connection of the supports for the current conductors, and the design shall be such as to permit removal and replacement of the supports after the enclosure is embedded in the concrete. Shipment shall be made in sections not to exceed about twenty feet in length.

5-13. PIER NOSE ARMOR. - Pier nose armor shall consist of heavy steel angles with strap anchors welded on. At the south bulkhead the armor shall be of heavy plate bent to the shape of the bulkhead corner and with strap anchors welded on.

SECTION VI - FABRICATION OF STRUCTURAL STEEL

6-01. GENERAL. - Fabrication of structural steel shall be in accordance with Section 25 of the "Specification for the Design, Fabrication and Erection of structural steel for Buildings" as adopted by the American Institute of Steel Construction and revised in 1936, except as may be otherwise noted in these specifications. Fabrication of plate girders shall be in accordance with Section V of the American Railway Engineering Association's "Specifications for Steel Railway Bridges" dated 1940.

6-02. WELDING.

(a) General. - All welding except as otherwise specified shall be done in accordance with the applicable current Codes, Specifications, and Recommended Practices of the American Welding Society.

Parts to be welded shall be rigidly held by sufficient clamps or other adequate means to keep the parts in close contact and in accurate position. Adequate precautions shall be taken to minimize locked-up stresses and distortion due to heat.

Fillet welds in sizes up to 1/4 inch shall be made in one pass, and larger welds shall be made in two or more passes. Successive beads or layers shall be uniform in thickness.

Each layer of weld metal shall be thoroughly cleaned before subsequent layers are deposited. Upon completion, each weld shall be thoroughly cleaned and brushed with wire brushes, and extraneous nodules of weld metal shall be removed by chipping.

Wherever there is danger of the assembled structure or member becoming warped or distorted by localized welding stresses, the welds shall be thoroughly peened with a pneumatic tool to relieve such stresses.

All welds shall be free from unsound metal, cracks, overlap, and feather edges. Minor imperfections in welds may be chipped out and the defect rewelded, subject to approval. Distortions due to welding or stress-relieving shall be corrected by pressing and not by blows.

Welding shall be done only by welders properly qualified in the work of the actual process employed. The contractor shall assign to each welder an identifying number, letter or symbol which shall be stamped in the metal adjacent to and at intervals of not more than three feet along all welds which he makes.

(b) Qualification of Welders. - Before beginning the production of welded work, the contractor shall furnish to the contracting officer satisfactory evidence, in the form of a certificate by a recognized testing agency or by actual demonstration, that each welder to be employed on the work of this contract has within one year of the date of this contract satisfactorily performed the qualification tests prescribed by the American Welding Society in its "Code for Fusion Welding and Gas Cutting in Building Construction" (Latest Edition), using the detailed procedure to be followed in actual production under this contract.

The contractor shall require any welder to repeat these tests when in the opinion of the contracting officer the work indicates a reasonable doubt of the welders efficiency.

6-03. WORKMANSHIP. - All workmanship shall be first class and shall be done by workmen skilled in their various trades. Tolerances, fits, and finish shall conform to the best modern shop practice in the manufacture of finished products of a nature similar to those covered by these specifications. Particular care shall be taken that the surfaces on the guide towers to which the gate track rails are to be fastened are truly plane after the towers are completely fabricated.

6-04. PREPARATION FOR SHIPMENT. - The contractor shall prepare all materials and articles for shipment in such manner as to facilitate handling and to protect them from damage in transit; and shall be responsible for and shall make good any and all damage due to improper preparation and loading for shipment. All threads and finished surfaces shall be protected as specified in Section VIII. All small parts shall be contained in properly marked boxes and each box shall contain a list showing the contents. Each shipping piece shall be marked in accordance with approved assembly drawings. Marks shall be legible and so placed as to be visible when the piece is being erected. Each piece weighing more than one ton shall have its approximate weight marked on it.

SECTION VII - MATERIALS

7-01. GENERAL.

(a) Materials. - All materials shall be of new unused stock, free from defects. Substitution of size of sections and materials from that shown on the drawings or required in the specifications shall not be made except on written approval of the contracting officer and provided that the cost to the Government shall not be increased thereby.

Materials indicated on the drawings or required in the work and not covered elsewhere in these specifications by detailed requirements, shall conform to the requirements of this section.

Any materials required which are not covered by detailed specifications herein or elsewhere in the specifications shall conform to the applicable Federal Specifications, grade and/or class as required or, in case where there are no applicable Federal Specifications, to applicable specifications of the American Society for Testing Materials (A.S.T.M.). In all other cases not specifically covered in these specifications the contractor shall furnish the highest grade commercial material or product.

(b) Inspection, Acceptance and Rejection of Materials. - All materials shall be subject at all times to inspection by the contracting officer who will select such samples in such quantities as he may deem necessary and subject the same to such tests as may be necessary to determine their qualities as herein specified, and he will accept or reject materials in accordance with the results of such tests. Tests may be repeated upon arrival of the various shipments at the site of the work as may be necessary to insure the acceptance of only such materials as will comply with the provisions of the plans and specifications.

(c) Test Specimens. - Special test specimens shall be furnished by the contractor on request; and shall be of such shape and number as designated; and shall in general conform to Federal Specifications or the specifications of the American Society for Testing Materials as to shape, size, and method of testing.

(d) Mill test reports. - Mill test reports certified to by qualified technicians shall be furnished when required for all material entering into this work and will, in general, be the basis of acceptance or rejection of the materials. The contracting officer may however, require of the contractor special chemical or physical tests on any part of the material if in his opinion the conditions justify such a check.

(e) Federal Specifications. - Copies of Federal Specifications referred to herein may be procured from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a price of five or ten cents each. When the term: "Federal Specifications" or "A.S.T.M. Specifications" is cited, the reference shall be construed to mean the specifications as modified by an amendments promulgated before the date of opening bids for the contract.

7-02. STRUCTURAL CARBON STEEL. - Structural carbon steel shall conform to Federal Specification QQ-S-711a for "Steel, Structural; (for) Bridges", Class A. Surface imperfections shall be remedied by arc-welding and according to Government practice. The chemical properties of the steel shall be such as to permit it to be readily welded by this process.

7-03. RIVET STEEL. - Rivet Steel shall conform to Federal Specification

QQ-S-711a for "Steel, Structural; (for) Bridges", Class C.

7-04. STRUCTURAL SILICON STEEL. - Structural silicon steel shall conform to the standard Specification of the American Society for Testing Materials for "Structural Silicon Steel", Designation A 94-39.

7-05. CORROSION-RESISTING STEEL. - Corrosion-resisting steel for seal guides shall conform to the Standard Specification of the American Society for Testing Materials for "Corrosion-Resisting Chromium Steel Sheet, Strip and Plate", Designation A176-39, Grade 2 (Type 410), and shall be cold-rolled or cold-drawn, pickled finish, and have Brinell hardness of 220 to 260.

Corrosion-resisting steel for bolts, studs and nuts shall conform to Federal Specification QQ-S-763 for "Steel, Corrosion-Resisting; Bars and Forgings", Grade 6, with sulphur content of 0.18-0.35 percent with phosphorus 0.04 percent (maximum); and shall be free-machining and suitable for threading and upsetting.

7-06. BOLTS AND NUTS.

(a) Unless otherwise specified or called for on the drawings, the material for bolts and nuts shall conform to the Standard Specification of the A.S.T.M. for "Commercial Quality Hot Rolled Bar Steels", Designation A 107-40, Grades 22, 23, 24, or 25.

(b) The material for bronze bolts and nuts shall conform to Federal Specification QQ-B-636 for "Brass, Naval; Bars, Plates, Rods, Shapes, Sheets, and Strips", Type I, half hard.

(c) The material for bolts and nuts of "high strength steel" shall conform to the Tentative Specification of the A.S.T.M. for "Alloy-Steel Forgings for General Industrial Use", Designation A 237-40T, Class D.

7-07. STEEL RAILS. - The crane track rails shall be new, 175 pound, section 175-418, and shall conform to the Standard Specifications of the American Society for Testing Materials for "Open-Hearth Steel Girder Rails of Plain, Grooved, and Guard Types", Designation A2-27, Class A, No. 1. The rails shall be heat-treated throughout their length and cross section by heating uniformly to above the critical temperature, quenching and tempering to produce a Brinell hardness of 320 to 350. All heating, quenching and tempering shall be done with equipment which will accommodate the entire length of each piece. After heat-treatment, the rails shall be smooth on the head and the required curvature of the rail axis maintained.

7-08. SPLICE BARS. - All splice bars shall be new and shall conform to the Standard Specification of the American Society for Testing Materials for "Low-Carbon-Steel Joint Bars", Designation A 3-33.

7-09. RAIL CLIPS. - Rail clips shall be either structural steel, forged steel or cast steel, in accordance with the standard practice of the contractor.

7-10. FLOOR GRATING. - Floor Grating shall conform to Federal Specifications RR-G-661a for "Grating, Steel, floor (Except for Naval Vessels)", Type I with welded cross members and of dimensions as shown on drawings.

7-11. WELD RODS AND DEPOSITED WELD METAL. - Weld rods shall be of the heavily-coated type. Electrodes for welding stainless steel to structural steel or component parts of stainless steel shall be heavily coated stainless

steel wire, American Iron and Steel Institute, type 309. Deposited weld metal shall have a corrosion resistance at least equal to that of mild steel. The ultimate strength of the metal shall be not less than 60,000 pounds per square inch and the elongation in 2 inches not less than 20 percent.

7-12. REINFORCING STEEL; CONCRETE. - Reinforcing steel shall conform to Federal Specification QQ-B-71a for "Bars; Reinforcement, (for) concrete", Type B. Straight bars shall be Grade 2 (Intermediate, Billet Steel), Grade 4 (Hard, Billet Steel) or Grade 5 (Hard, Rail Steel). All bent bars shall be of Grade 2 (Intermediate, Billet Steel) or Grade 3 (Intermediate, Car Axel Steel). The steel shall be properly identified as to grade.

SECTION VIII - PAINTS AND PAINTING

8-01. GENERAL. - All paint, when applied, shall provide a satisfactory film and a smooth even surface, and undercoats shall dry without excessive gloss, suitable for the proper application and ahesion of subsequent coats, as approved by the contracting officer. Where necessary, in the opinion of the inspector, to suit the conditions of surface, temperature, and weather existing at the particular time of application, the packaged paint may be thinned by the addition of not more than one pint of the proper thinner immediately prior to application, provided that in no case shall the viscosity of the paint be reduced to a point where the specified maximum coverages will be exceeded.

8-02. SURFACE CLEANING AND PREPARATION.

(a) Cleaning. - All ferrous surfaces to be painted shall be thoroughly cleaned of all loose millscale, rust, dirt, and other foreign substances to base metal by sandblasting, flame cleaning, or any other method approved by the contracting officer.

(b) Protection of Surfaces. - Care shall be taken to adequately protect all machinery parts, threads, and finished surfaces during cleaning and preparation.

8-03. PAINT APPLICATION.

(a) All painting shall be done in a neat, thorough, and workmanlike manner. Except where otherwise specified or specifically directed, all paint coats shall be applied by either brush or spray in such manner as to produce an even coating of uniform thickness completely coating all corners and crevices. All painting shall be done by thoroughly experienced workmen. Care shall be exercised during spraying to hold the nozzle sufficiently close to the surfaces being painted to avoid excessive evaporation of the volatile constituents and loss of material int the air. Paint shall be applied only to surfaces that are THOROUGHLY dry and only under such combination of humidity and temperatures of the atmosphere and surfaces to be painted as will cause evaporation rather than condensation. (A practical test is to wipe a damp cloth on the surface to be painted. If the moist streak dried promptly, conditions conducive to evaporation prevail.) In no cases shall any paint be applied to surfaces upon which there is frost or moisture condensation, or during rainy or misty weather, without suitable protection as approved by the contracting officer. Painting during unfavorable weather conditions shall be carried on in a heated building. While any painting is being done, the temperature of the surfaces to be painted and of the atmosphere in contact therewith shall be maintained at or above 50 degrees F. All paint when applied shall be approximately (within fifteen degrees of) the same temperature as that of the surface on which it is applied. Where protection is provided for paint surfaces, such protection shall be preserved in place until the paint film has properly dried and removal of the protection is authorized by the contracting officer. Movable parts, hardware, and other surfaces not required to be painted shall be cleaned to the satisfaction of the contracting officer.

(b) Coverage. - The surface area covered per gallon of paint specified shall be not greater than 425 square feet per gallon.

8-04. PRIMING COATS.

(a) Unpainted Surfaces. - The surfaces of all ferrous metal work to be embedded (except as noted in (e)), non-ferrous metal-coated surfaces, machined surfaces, surfaces requiring welding, and surfaces which will be in riveted contact shall not be painted. All other exposed ferrous surfaces, unless otherwise specified shall receive one priming coat of Synthetic Red Lead Primer.

(b) Structural Parts shall receive one shop priming coat.

(c) Machined Surfaces shall, immediately after final inspection, be thoroughly cleaned of all foreign matter and coated with a heavy film of Rust Preventive Compound, U. S. Army Specification 2-84A.

(d) Screw Threads shall be protected by a coating of heavy oil.

(e) Gantry and Railroad Girders shall receive one shop priming coat of Synthetic Red Lead Paint.

8-05. PAINTS AND PAINT FORMULAE.

(a) General. - Paints shall have the composition as indicated below or as otherwise approved by the contracting officer. All paints shall be guaranteed by the manufacturer not to gel, liver or thicken deleteriously or form gas in a closed container within a period of one year from date of manufacture.

(b) Processing of Paints.

(1) Except where otherwise specified or authorized, all paint shall be made by grinding together dry or paste pigments and a liquid vehicle to form a smooth paint that will flow freely and will not settle or react deleteriously in containers.

(2) Grinding shall produce a fineness such that coarse particles and skins will not exceed 1.5 percent (total residue left on No. 325 mesh screen, based on pigment). The grinding shall be done in a roll or pebble mill at temperatures that will not cause polymerization.

(3) Skinning shall be negligible after exposing 6 ounces of paint in a tightly closed 8 ounce glass container to sunlight for a total time of 24 hours.

(4) The resulting paint shall have satisfactory brushing and leveling properties, shall set to touch in not less than one hour nor more than four hours, unless otherwise specified, and shall provide a satisfactory film and a smooth even surface without undue gloss, suitable for proper application and adhesion of subsequent paint coats, as approved by the contracting officer. Sufficient suitable driers shall be added to make the paint dry hard within 18 hours.

(5) In view of potential variations resulting from variable processing equipment and technique, the manufacturer may be allowed, where necessary to produce the specified viscosities, to make slight changes in formula proportions, subject to specific approval of the contracting officer.

(c) Synthetic Red Lead Primer, to be used under all gray enamel finish coats shall be composed of materials conforming, where applicable, to the specified requirements and shall be mixed in proportions as follows:

Red Lead	16.5% by weight
Iron Oxide	38.2%
Zinc Yellow	5.5%
Diatomaceous Silica	6.0%
Vehicle(see Par. 8-06)	28.0%

Synthetic Red Lead Primer, (Cont'd)

Thinner----------5.8%

The paint shall have a consistency of flow of between 25 and 40 seconds through the 0.15 inch diameter orifice of a standard consistency cup when tested in accordance with the procedure specified in paragraphs 9 and 10 of A.S.T.M., Specification D 333-37 for "Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels". It shall have satisfactory brushing and leveling properties, shall set to light touch in not less than 2 hours not more than 5 hours, and shall dry hard for recoating in not more than 18 hours, when tested in accordance with paragraph P-2d of Federal Specification TT-V-81a, entitled "Varnish; Mixing (for) Aluminum Paint". The vehicle shall be a synthetic resin varnish consisting of a phenol formaldehyde resin with the necessary oils and volatile thinners to produce elasticity, waterproofness, adherence, and durability in the finished paint film. It shall meet the detailed requirements of paragraph 8-06.

8-06. PHENOLIC RESIN VARNISH VEHICLE shall conform to the following requirements:

(a) Oil-resin ratio shall be 33 gallons of oil to 100 pounds of resin.

(b) Shall be clear and transparent and entirely free from resin, estergum or other non-phenolic resisn. Not less than 50 percent by weight of the vehicle shall consist of non-volatile oil and resin.

(c) The resin content shall be 100 percent para-phenyl phenol-formaldehyde condensate similar and equal to Bakelite BF 254, and shall conform to the current U. S. Navy Department Specification 52R10 entitled "Resin Phenol-Formaldehyde".

(d) The volatile thinner shall contain not more than 80 percent mineral spirits and not less than 20 percent high flash coat tar naphtha or high flash hydrogenated petroleum naphtha and shall be free from toxic hydrocarbons such as benzol.

(e) The oil content shall be a ternary oil mixture composed of 40% linseed, 30% liquid oiticica, and 30% "dehydrated" castor oil.

(f) The flash point shall be not below 30 degrees C. in a closed cup tester.

(g) Shall pass a Kauri Reduction Test of 120 percent, using the method described in paragraph F-2g, Federal Specification TT-V-81, for "Varnish; Mixing (for) Aluminum Paint".

(h) Shall show no skinning after 48 hours in a 3/4 filled, tight container.

(i) Flow-out films on tin plate panels dried 72 hours shall withstand immersion in cold water for 96 hours, and in distilled water at 200 degrees F. for 7 hours without showing more than a slight haze which shall disappear within one hour, and shall show no other signs of deterioration. The panel shall be allowed to dry and cool for 15 minuted after removal from hot water and shall then be inspected for signs of failure.

8-07. PIGMENTS.

(a) Carbon Black shall conform to either Federal Specification TT-B-601 entitled "Boneblack; Dry, Paste-in-Japan, Paste-in-Oil" or Federal Specification TT-L-71 entitled "Lampblack; Dry, Paste-in-Japan, Paste-in-Oil".

(b) Lead Titanate shall be similar and equal to Titanox "L" as manufactured by the Titanium Pigment Corporation.

(c) Red Lead shall conform to Federal Specification TT-R-191a (97) percent Grade for "Red Lead; Dry and Paste-in-Oil".

(d) Iron Oxide shall contain not less than 98 percent Fe_2O_3 and shall not contain any organic coloring matter.

(e) Diatomaceous Silica shall be an approved commercial grade.

(f) Zinc Yellow shall contain not less than 40 percent CrO_3. It shall be a basic zinc potassium chromate, soluble in acetic acid, free from lead compounds, and containing no added zinc oxide, and shall be stable or non reactive with the pigments and vehicles specified.

(g) Titanium Dioxide shall be similar and equal to either "Ti-Pure O" as manufactured by Krebs Pigment & Color Corporation or "Titanox NC" as manufactured by the Titanium Pigment Corporation.

8-08. THINNERS AND SOLVENTS.

(a) Mineral Spirits shall have the following properties:

Gravity- - - - - - - - - - - - - - -	43-47 degrees Baume
Flash Point (Closed cup) - - - - - - - -	100 degrees F. Min.
Initial Boiling Point- - - - - - - - - -	300-310 degrees F.
End Point- - - - - - - - - - - - - - - -	405 degrees F. Max.
A.S.T.M. Copper Strip Test - - - - - - -	Negative
Solvency (Kauri-Butanol) - - - - - - - -	41 cc (a) 77 degrees F. Min.

(b) Dipentine shall have the following properties:

	Maximum	Minimum
Specific Gravity at 15.5 degrees C.	0.854	0.845
Refractive Index at 20 degrees C.	1.477	1.472
Unpolymerized Residue (percent (38N H_2SO_4)	2.5	
A.S.T.M. Distillation Range:		
5% Distilling at - - - - - - - - -	-173 degrees C.	
10% Distilling at - - - - - - - - -	-175 degrees C.	
97% Distilling at - - - - - - - - -	-188 degrees C.	
Color-Lovibond 500 Amber- - - - - -	3	
Appearance: Clear and free from suspended matter.		

(c) Toluol shall conform to U. S. Navy Department Specification 52T7 entitled "Toluene (Toluol)", except that it shall have a solvency (Kauri-Butanol Method) of not less than 100 cc at 77 degrees F.

(d) Xylol shall conform to A.S.T.M. Specification D364-36 for "Industrial Xylene (Xylol) or 'Solvent Naphtha'", except that it shall have a solvency (Kauri-Butanol Method) of not less than 93 cc. at 77 degrees F.

(e) Normal Butyl Alcohol (Butanol) shall conform to A.S.T.M. Specification D304-33 for "Butanol (Normal Butyl Alcohol)".

(f) Ethylene Glycol Monoethyl Ether shall conform to A.S.T.M. Specification D331-35 for "Ethylene Glycol Monoethyl Ether."

8-09. MISCELLANEOUS MATERIALS.

(a) Oil, Linseed shall conform to Federal Specification JJJ-O-331 for "Oil; Linseed, Boiled", or JJJ-O-336, for "Oil; Linseed, Raw", as specified or required.

(b) Insulating Varnish, U. S. Navy Department Specification 52-V-13b, entitled "Varnish; Insulating, (for) Electrical Purposes".

(c) Creosote Paint for surface treatment of timber shall conform to Federal Specification TT-W-561a, entitled "Wood-Preservative; Creosote (for) Brush and Spray Treatment".

(d) Ortho-Phosphoric Acid (H_3PO_4), shall be commercially pure product, in liquid form, containing not less than 75 percent H_3PO_4.

(e) Sodium Dichromate, ($Na_2Cr_2O_7.2H_2O$) shall be a commercially pure product in crystalline form containing not less than 85 percent $Na_2Cr_2O_7$.

8-10. INSPECTION.

(a) Unless otherwise specifically authorized, inspection of all materials for the paints and chemical rust inhibitor and the manufacture thereof, will be made by a representative of the contracting officer. All samples of materials and of the finished processed products will be tested and analyzed for conformity with the specifications by the Government. The inspector will collect for testing, samples of each of the materials to be used in the manufacturing processes and will then seal the material containers until test results from the samples indicate that the various materials conform to specifications. He will witness the breaking of the seals on the approved material containers and the compounding of the materials for the product being manufactured, will collect samples of the finished product for testing, and will witness the placing, sealing, and labeling of the finished product in containers for shipment. After the finished products have successfully passed the prescribed test, shipment of the sealed containers will be authorized.

(b) In the case of ready-mixed and packaged paints of standard manufacture, other than those specified by tradename, the contractor shall furnish a sample in the standard stock package, together with a certified copy of the complete chemical analysis, for test and approval by the contracting officer.

8-11. PAYMENT for all paint and painting will be included in the contract price for the respective metals or items painted.

LONG SAULT DAM

Specifications

For

SPILLWAY GATES

SECTION II

SPILLWAY GATES - GENERAL FEATURES

2-01. GENERAL.

(a) The following shall constitute the materials and equipment that are included under the "Spillway Gates":

(1) Thirteen gates complete, for use temporarily in river diversion and the component sections for use later on the permanent spillway including structural steel frames and skin plates, wheels, lubrication systems and fittings, guide pins and sockets, water seals, (both temporary and permanent) lifting and coupling devices, and tools.

(2) One lifting beam which will be connected to the lifting blocks of the crane, complete with structural frame, guide rollers, guide pins, lifting and coupling devices similar to those on the gates, and connecting links to the crane sheave blocks.

(3) The diversion gate dogging devices which are to be installed in the concrete piers, including all castings, pins, push rods, levers, hand wheels or other operating devices, bushings, bolts, and lubrication systems and fitting, but not including the structural steel grillage, anchor bolts, pipe casings, and supports for the dogs which are embedded in the concrete.

(4) The gate track rails with supporting beams and the bearing supports for the diversion gates; including all rail clips, splice bars, machine bolts, anchor bolts, and other appurtenances.

(5) One portable, electric motor-operated grease compressor for lubricating the gate wheel bearings, and the dogging machinery.

(b) The contractor shall coordinate his designs and detailed drawings with those of related structures by means of drawings or information which will be furnished by the contracting officer.

(c) Hole which are to be used for connection of equipment not furnished by the contractor shall be drilled or reamed to metal template furnished by the contracting officer or made from information given by him; or drilled or reamed with the parts assembled. All templates, all casting patterns, and all molds for rubber seals shall be and remain the property of the Government.

(d) The remainder of the gates to be used temporarily for diversion, together with tracks, dogging equipment and other appurtenances; and the gates to be used only in the permanent spillway slots, together with all spillway gate tracks, additional dogging equipment, a second lifting beam and other appurtenances are not included in this contract, but will be furnished under subsequent contracts.

2-02. GATES AND LIFTING BEAMS.

(a) The thirteen gates required for temporary use in river diversion are made up of thirteen single section permanent gates, each coupled to the top section of a permanent double section gate which rests on top of the single section. No bottom section of the double section gates are required under this contract. Each complete single section gate is 25'-8" high and all sections are about 53 feet in overall length. The top sections required are: six 17-foot high sections, six 14-foot high sections, and one 12-foot high section. Each single section gate is equipped with a lifting device

and each top section is equipped with lifting and coupling devices. When the gates are used for diversion the sections are always coupled together, but for permanent use on the spillway the crane operator may operate the two sections of the double section gates either as a single unit or separately.

(b) Each gate section consists of a steel skin plate on the upstream side (when the gates are in the permanent spillway slots) riveted to a supporting steel frame work of vertical and horizontal girders and stiffeners. The bottom and side edges of each section are equipped with water seals. The water load on each section is distributed by the skin plate and stiffeners to the horizontal girders, and thence to the vertical girders at the sides. Double flanged wheels on over-hung axles are mounted on the vertical girders and take the horizontal load on the gate into the gate tracks on the piers.

(c) The lifting beam consists of a structural steel frame with lifting and coupling devices similar to those in the top sections of the gates. The beam spans the entire opening and the ends are equipped with guide rollers. The cross heads of the lifting device are coupled to the lifting blocks of the crane.

(d) The position, with reference to the skin plate, of the center line of lifting hooks shown on the drawings is dependent upon the center of gravity of the single section gate. The final position of the lifting hooks shall be subject to the approval of the contracting officer after a weight estimate is secured. The position of the hooks shall be the same for all gate sections and counterweight shall be added if directed by the contracting officer.

2-03. DIVERSION GATE DOGGING DEVICES.

(a) Twenty-six pairs of dogs are provided in the pier noses for openings 1 to 13 inclusive for use during river diversion for dogging the river diversion gates. Two dogs are mounted on each side, of each pier nose, one directly above the other and operated independently from the pier top by the same push rod. It is intended that the dog castings and pins will be salvaged after use for the diversion gates and installed in the permanent spillway gate slots.

(b) The dogs are of the vertical reaction type and are operated by vertical push rods through pipe shafts and connected to hand wheels or other suitable operating devices at the top of the piers. The gates may be dogged at various elevations, the dogging steps being the treads of the gate wheels. The dog castings pivot on horizontal pins set in structural steel supports which are embedded in the piers. Pins are lubricated by means of copper tubing running through the pipe shafts to the tops of the piers and terminating in button-head grease fittings.

2-04. DIVERSION GATE TRACKS. - The tracks for the diversion gates are vertical crane rails clamped to wide-flange beams which are anchored and grouted in the niches near the upstream ends of the piers for gate openings 1 to 13 inclusive. A plate, continuous from the elevations shown on the drawings to the top of the track beam, is welded to the downstream flange and flush with the inner surface of the flange. This plate forms part of the vertical sealing surface for the gate seal. Anchor bolts with provision for adjusting the tracks laterally and in an up-and-downstream direction will be furnished by this contractor and set in the piers by the Government.

SECTION III

DESIGN LOADS AND STRESSES

3-01. GATES AND DIVERSION GATE TRACKS.

(a) Gates in Permanent Position on Spillway. - All parts of the gates shall be designed to withstand either of the following loading conditions in addition to stresses due to lifting, lowering, or resting on the sill.

(1) A horizontal water load corresponding to a water surface on the upstream side at Elev. 249, which is three feet above the top of the gates.

(2) A horizontal ice load of 10,000 lb. per lineal foot of gate length between pier faces, distributed over 4 feet vertically, and with its center of pressure at any point between Elev. 229.5 and Elev. 244; and , in addition, a water load corresponding to a surface 6" below the ice surface.

The tailwater will be below the gate sill for both conditions. The weight of water shall be taken as 62.5 lb. per cubic foot.

For Condition 1. the unit stresses in structural carbon steel shall not exceed those corresponding to an 18,000 lb. per square inch base as specified in the American Institute of Steel Construction's "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" as revised January 1934, except that the thickness of all members shall be increased 1/16" above the resulting designed thickness to allow for corrosion. The unit stresses in structural silicon steel shall not exceed those corresponding to a 24,000 lb. per square inch base, and the resulting designed thickness shall be increased 1/16" to allow for corrosion. The unit stresses for other materials shall not exceed those normally used, in good practice, for the materials involved. The radial wheel loads shall not exceed 180,000 lb.

For Condition 2, the unit stresses in any material shall not exceed 125% of those allowed for Condition 1, except that no allowance shall be made for corrosion. The radial wheel loads shall not exceed 225,000.lb.

(b) Gates in Temporary use for River Diversion. - The full depth (25'-8") gate sections shall also be capable of withstanding a water pressure corresponding to water surface 17 feet above the top of the gate and acting against the skin plate from the side of the gate which normally faces downstream. All of the top sections shall be capable of withstanding a pressure corresponding to a water surface at the top of the section and acting against the skin plate from the side of the gate which normally faces downstream. This loading condition is shown on Drawing BD-1-30/1 and occurs when the gates are used for river diversion during construction. Under this condition, unit stresses in the component parts of the gate shall not exceed 150% of those specified for Condition 1, or 80% of the yield point of the materials involved. Tension on rivets in the skin plate shall not exceed 2,500 lb. per sq. inch of nominal rivet area. No ice loads need be considered for this design condition.

(c) Diversion Gate Tracks. - The tracks for the diversion gates shall be designed to sustain the maximum wheel loads and to transmit them in bearing to the concrete of the pier without overstressing the steel or the supporting concrete.

3-02. LIFTING AND COUPLING DEVICES.

(a) All parts of the lifting and coupling devices, including those in the lifting beams and the structural parts affected in the gates shall be designed for a vertical load (per gate) of 525,000 lbs. in order to take care of the diversion gate loads. The unit stresses shall not exceed those normally used, in good practice, for the materials involved. Each wedge, and all parts of the wedge-operating machinery, shall be designed for a thrust of 3,000 pounds in the screw shaft. Each wedge shall be designed to support a vertical load from the coupling tie bars of 120,000 pounds.

(b) All guide pins and sockets for centering gate sections and lifting beams shall be capable of transmitting, at normal working stresses, reactions due to wind pressure on the full depth gate section while it is suspended from the crane. Wind pressure shall be assumed at 40 lb. sq. ft. maximum and the gate area 1350 sq. ft.

3-03. DIVERSION GATE DOGS. - Each pair of dogs and dog pins at the same elevation in the pier noses (to be used for supporting the river diversion gates)shall be designed to support a load of at least 133% of the weight of the heaviest river diversion gate, but for not less than 575,000 lbs. The unit stresses shall not exceed those normally used, in good practice, for the materials involved.

SECTION IV

STRUCTURAL DETAILS

4-01. GATES. (Riveted Design)

(a) The general construction of the gates shall be substantially as shown on the Government's drawings. Riveted construction shall be used, in general, but welding will be permitted for calking joints, plugging holes, and for construction of the temporary seal structure. If approved by the contracting officer other minor details may be welded. In all cases, welding and rivcting shall conform to the provisions of Section VIII. All parts of the gates shall be adequate to transfer the loads specified from their points of application to the track rails without exceeding the unit stresses specified and without excessive deformation. Except as provided below, the gate structure shall be of structural carbon steel.

(b) Structural silicon steel shall be used where called for on the drawings or in these specifications and, except for the skin plate, may be used for other structural parts, provided no horizontal girder deflection under maximum design load for any of the prescribed conditions of loading shall exceed 7/8".

(c) In designing the horizontal girders a width of the skin plate equal to the distance between the outer rivet gauge lines in the outstanding angle legs plus 24 times the skin plate thickness, may be figured as cover plate area. Proper allowances shall be made for unsymmetrical sections and for combined stresses.

(d) All connections and details shall be of sufficient strength to develop the full strength of the parts connected, and each connection shall have at least two rivets. The minimum rivet size shall be 7/8". Details shall be such as to give free access for inspection and painting, and all water pockets shall be drained.

(e) The bottom girders of each gate section shall be air-vented to minimize suction.

(f) All gate sections shall be completely shop-fabricated except the 25'-8" gates and the 17'-0" top sections which shall be built in two pieces each with provisions for horizontal field splicing. The design of the splices shall be such as to require as little field work as possible, consistent with strength and watertightness requirements.

(g) The top of each 25'-8" gate section shall be flat and smooth with all rivets in the horizontal sealing surface area counter sunk.

(h) Provision shall be made so that a man may readily reach and operate by hand or service the wedge operating mechanisms and the devices for emergency hand operation of the coupling links. The top sections of the double section gates shall have a ladder near each end on the side opposite the skin plate for access to the wedge operating machinery and the coupling device crossheads.

(i) The design for Condition 2 shall take into account the transfer of load from any horizontal girder to the adjacent girders through the vertical diaphragms.

(j) Care shall be taken in the design that proper clearances are maintained between the gate and the dam structures at all points.

(k) Each gate section shall be equipped with connections for latching to the lower sill on the upstream side of the crane when the section in being

transported by the crane. The connections shall be designed to withstand their proportion of the horizontal wind load specified in Paragraph 3-02(b).

(l) Each gate section shall be equipped with connections at the top for up-ending the section from a flat position with the skin plate down. The connections may be removable and shall be suitable for attching the crane sheave blocks and of adequate strength to sustain their proportion of the dead load of the gate section. It will be necessary to make use of these connections when a gate is lowered into or raised from the gate repair chamber.

(m) To fit the gates for temporary use for diversion operations as noted in 3-01(e) and shown on drawing BD-1-30/1 a temporary steel seal structure shall be attached to the skin plate side of each gate section by riviting or welding. Proper provision shall be made for splicing at the horizontal splices in the gates and at the joint between the top of each single section gate and the bottom of the top section which rests upon it. The seal retaining slot shall be continuous along the sides and bottom of the full-depth gate section and shall be mitered at the corners. The seal structure shall be capable of withstanding (without leaks, overstressing, or excessive deflection) a hydrostatic pressure corresponding to a forty-foot head on the bottom seal. There shall be clearance between the seal structure and the sealing surface when the gate is under maximum load and the seal shall have sufficient movement in a direction perpendicular to the face of the gate to be effective when the gate is under no load. Details of the design shall be such as to hold to a minimum the work and material necessary to convert the diversion gates to permanent spillway gates.

4-02. GATES (Alternate Welded Design)

The contractor may, at his option, submit designs for all welded gates as an alternate to the riveted design shown on the Government's drawings and described in paragraph 4-01. If the design and details are satisfactory to the contracting officer, the welded design will be approved for the construction.

4-03. DIVERSION GATE TRACKS. - The track rails shall be 175 lb., heat-treated Lorain crane rails, Section No. 175-418, and shall be clamped to the flange of the vertical track beam. The upstream beam flange shall be planed and the head of the rail shall be straight in line after the rail clips are drawn tight. The beam webs shall be stiffened by welded plates and the flanges cut for proper clearance. Provision shall be made for an adjustment, for setting the position of the rail head in the field, of ½-inch laterally in either direction and 3/8-inch either upstream or downstream, both from the normal position as shown on the drawings. Holes in the rail web and beam flanges and clearance in the rail clips shall be large enough to allow the adjustments required. The rails shall be matched for height at the splices and joints ground smooth.

SECTION V

MECHANICAL DETAILS

5-01. LIFTING AND COUPLING DEVICES.

(a) The lifting and coupling device for each top section shall be essentially as shown on Drawing BD-1-40/2 and shall consist of swinging links suspended on horizontal pins from crossheads connected by tie bars to double hooks at the top of the gate section. The hook links engage similar hooks in the bottom gate section. Each pair of hook links is geared together to operate in unison and the two pairs in each gate section are mechanically interlocked to provide simultaneous operation. A latch to hold the links open and a latch tripper to allow them to close are provided in each cross-head and are operated by the vertical movement of the cross-head. The lifting beam is provided with similar cross-heads and links. Emergency hand operation is provided for the links in both the lifting beam and the gate sections. Electric-motor operated wedges near the top of the gate serve to hold the sections together for operation as a unit.

(b) For permanent spillway gate operation the device is intended to perform the following functions by means of the crane with one crane operator (one additional man is required when connecting or disconnecting the gate sections):

(1) Connect the lifting beam to or disconnect it from the top of any gate and raise or lower the gate as desired.

(2) Connect the lifting beam to, or disconnect it from, any top gate section-or any bottom gate section when no water is flowing over it - and raise or lower the gate section as desired.

(3) Connect any upper gate section to, or disconnect it from, any lower gate section.

(c) The functions are performed as follows:

(1) (2) The lifting beam is lowered until it rests on top of the gate or gate section and the crane operator continues to lower the lifting beam cross-heads until the links engage the lifting hooks. The crane operator may then reverse the hoist motor and raise the gate after the small upward movement of the cross-head is taken up.

(3) To disconnect the gate sections the lifting beam is lowered until the top hooks are engaged as in (1) and (2). The hoist motor is then reversed and the lifting beam cross-heads and links are raised a short distance, elongating the coupling bars slightly so that the wedges near the top of the gate may be withdrawn by starting the wedge-operating motors. After the wedges are removed the lifting beam cross-heads are again lowered, together with the cross-heads in the gate, until the links in the gate cross-heads spread enough to allow the latches to drop and hold them open, disconnecting the sections. The top section may then be removed by hoisting until the gate cross-heads come in contact with the upper stops. Before the cross-heads reach the upper stops the latches are tripped by adjustable set screws allowing the links to drop into position to engage the hook when it is desired to connect the sections again. To connect the gate sections the top section is lowered until it rests on the top of the bottom section. The lifting beam is lowered further and the links in the gate cross-heads are spread by contact with the sloping of the hooks until they drop into position. The hoist motor is then reversed and the

whole assembly tightened so that the wedges may be driven and the lifting beam removed.

(d) For diversion gate operation the two gate sections are coupled and remain so until the diversion gates are dismantled to be converted to permanent spillway gates.

(e) Strength, simplicity and ease of operation shall be considered of prime importance in the design.

(f) Hooks, connecting castings, wedges and ligting links shall be alloy steel castings. Lifting links shall be equipped with self-lubricating bushings pressed in the link castings and doweled. Connecting bars shall be of structural silicon steel. The cross-heads shall be of structural silicon steel plates, or reinforced rolled sections, properly connected, braced, and finished to bear on the seats in the gate and lifting beam.

(g) Pins through hooks, connecting castings, and lifting links shall be of forged alloy steel and pin nuts shall be of pressed steel with recess and finished face. Lifting link latches and all levers and yokes in the mechanical interlock shall be carbon steel castings. Connecting links in the interlock shall be of structural carbon steel and pins of rolled nickel steel. All bearings for rotating or oscillating shafts and all bearing surfaces rotating or oscillating on fixed pins shall be fitted with self-lubricating bushings. Push rods shall be of standard weight black steel pipe with rods welded in at the ends and threaded right and left hand for adjustment. Yokes shall be threaded right and left hand to match. Rods shall be of bolt steel and shall be fitted with bronze jam nuts. The lever for hand operation of the links shall be of a carbon steel forging or casting.

(h) The speed reduction units connecting the threaded wedge operating rods to the drive motors shall be inclosed in felt-sealed, oiltight, cast steel or welded steel cases properly braced and connected to take the thrust of the wedge into the gate structure. The cases shall be provided with oil level plugs and drain plugs and the gear covers shall be easily removable for inspection of the gears. The gears shall run in a suitable lubricant, and lubrication shall also be provided for the threads of the operating rod. Lubrication shall be effective at temperatures down to -40° F. The wedge operating rods shall be of rolled nickel steel. Gears shall be of nickel steel, carburized. Bearings shall be of phosphor bronze. A flexible coupling shall be provided at the end of the high speed shaft for connection to the motor shaft. A weather-tight, copper-bearing sheet steel removable cover 1/8" thick shall be provided to inclose the entire mechanism except the wedge and operating shaft.

5-02. GUIDES.

(a) The lifting beams shall be provided with four double flanged rollers at each end which shall fit between the track and guide rails in the spillway gate slots and hold the beam, as it is lowered, in the proper position to engage the guide sockets on top of the gate. Clearance between rail heads shall be the same as the clearance of the gate wheels. When the beam is used for diversion gate operation, it will be guided by the track rails in contact with the downstream rollers. Rollers shall be equipped with press in self-lubricating bushings flanged to take end thrust, and provision shall be made for 7/16" slip of the roller on the axle in each direction. Vertical tapered guide pins, one near each end on the bottom of the beam, shall engage sockets in the gate with sufficiently close clearance so the lifting links will engage the hooks freely. Two sockets on the top of the beam shall engage guide pins on the crane trolley when the lift beam is in its highest position. Similar guide pins

and sockets shall be provided to guide the top section of the split gates to its proper position on top of the bottom section. The details at the end of the bear shall be such that the beam may be dogged in any gate slot.

(b) No guides are necessary for the gates themselves, the double-flanged wheels serving that purpose.

(c) The end guide rollers on the lifting beam shall be alloy steel castings. The guide pins on the lifting beams and top gate sections shall be alloy steel forgings provided with hexagon nuts of tobin bronze. The guide sockets shall be carbon steel castings and shall be bolted underneath the top girder web on each gate section with tobin bronze bolts. The bottoms shall be open to prevent filling with ice or debris.

(d) The diversion gates shall be provided with suitable guides at the sides for holding the gates in position as they are raised or lowered.

5-03. WHEEL ASSEMBLIES.

(a) General. -All parts of the wheel assembly shall be designed for a direct radial load of 180,000 lbs. and a sumultaneous axial load of 70,000 lbs. in either direction, both loads being applied at the wheel tread and while the wheel is either stationary or revolving at one-half revolution per minute.

The roller bearings shall be so proportioned as to sustain these combined loads with a factor of safety of not less than three, based on the ultimate strength of the material. They shall also be capable of sustaining, under test, a radial load of 300,000 lbs. combined with a thrust load of 100,000 lbs. applied at a point on the tread of the wheel, while revolving at a speed of one-half revolution per minute, without appreciable permanent deformation.

The axles shall be turned with a 1/8" accentric for aligning the wheels after the wheel assemblies are installed in the gate. Provision shall be made in the design for a slip of the wheel of 7/16" in either direction from the normal position to allow for variation in length of gate due to temperature changes and for tolerance in the track rail setting.

(b) Wheels. -The gate wheels shall be double flanged, heat-treated, rolled carbon steel.

(c) Axles. -Axles shall be alloy steel forgings, heat-treated to produce the following minimum physical results:

Tensile strength	100,000 lbs. per sq. in.
Elastic limit	75,000 lbs. per sq. in.
Elongation in 2"	19%
Reduction in area	50%

(d) Roller bearings. - The design of the roller bearings and their mounting in the wheels and on the axles shall be such that they may be readily removed and disassembled for inspection and cleaning. The races and rollers shall be of roller bearing alloy steel, heat-treated, and with bearing surfaces uniformly gardened to proper depth to insure sufficient strength to resist the maximum pressures between the bearing surfaces of rollers and races. Retainers shall be designed and constructed to properly space and guide the rollers with a minimum of friction.

(e) Hub Covers and Bearing Seal Covers. -Hub covers and bearing seal covers shall be of rolled steel, forged steel, or carbon steelcastings, and shall be designed to resist the thrust load on the wheel. Inside surfaces shall be sand-blasted or machined to remove all scale and sand or other foreign material.

(f) Bearing Seals. -Bearing seals shall be designed to prevent the entrance to the bearings of grit or of water under a static pressure of 20 pounds per square inch or less. Sealing material shall be made of flexible packing having

a low coefficient of friction. The physical characteristics of this material shall not be substantially affected by long exposure to air, water, mineral oil or extremes in temperature of the air which are likely to be encountered at the site of the dam. A spring device shall be incorporated in the seal to produce a uniform pressure of the sealing element around the shaft. The entire assembly shall have sufficient strength and rigidity to prevent leakage between the seal and the bearing seal cover in which the seal shall have a force fit. If external cages are used in the seal assembly, they shall be of non-corrodible metal or heavily cadmium-plated steel. If internal stiffeners are molded in the packing material, they may be of pressed steel or other approved metal. Springs shall be of bronze. "Klozure" seals as manufactured by the Garlock Packing Company, seals using "Neoprene" packing material with an internal stiffener ring as manufactured by the Michigan Leather Packing Company, or approved equal, will be acceptable.

(g) Bolts and Nuts. -Bolts and nuts for the hub covers and bearing seal covers shall be made from "high-strength steel". A spring steel lock washer shall be provided under each nut.

(h) Gaskets. -All gaskets shall be cut from compressed, asbestos-fibre sheet packing 1/32" thick. They shall be accurately cut to size with bolt holes 1/16" larger in diameter than the bolts.

(i) Lubrication Equipment and Lubrication. -The wheels on each side of each gate section shall be equipped with a centralized lubrication system, Farval or equal, with strainers and measuring valves. The grease supply to the bearings shall be taken from the supply lines through flexible tubing to the axles and thence through the axle to the bearings. Supply pipes shall be extra strong black wrought steel butt-weld pipe, pickled to remove all scale from the interior. Tubing shall be of copper with nominal wall thickness of 1/16" and with flared joint fittings of Marine and Refrigeration type. All pipe, tubing, and fittings shall be assembled with tight joints and shall be suitable for a cold oil working pressure of 2,000 lb. per sq. in. Fittings for connection to the compressor shall be of the button-head type. The fittings shall be easily accessible from the downstream side of the gate section and as close as practicable to the top of the section.

During or after assembly, the supply pipes, tubes and fittings, as well as the space surrounding the bearings and journals shall be completely filled with a lubricant recommended by the wheel bearing manufactured, or approved equal. Any lubricant selected shall be effective at 40 F.

5-04. PERMANENT WATER SEALS

(a) Side Seals. - The seals at the sides of each gate section shall be 2½" diameter staunching rods of corrosion-resisting steel fastened to the gate body by tobin bronze bolts. Proper allowance shall be made for tolerances in guides, track rails, gate structure and wheels in determining the movement of the seal in a direction parallel to the face of the pier. The rods shall be attached in such a way that when the gate is sealed the rods will be held against the sealing stripes on the downstream edges of the gate slots and water pressure on the upstream side of the gate will increase the pressure between the seal and seal strip. Details at the bottoms of the rods on any gate section shall be such as to cause the rods to slide down the sloping seal plate at the top without binding and to seal against the sill or against the top of the bottom gate section with a minimum of leakage. The seal supporting angles shall be shipped separately with the seals to be installed by others after river diversion operations are completed. Holes shall be reamed as noted in 8-02 and 8-09 to in-

sure correct assembly in the field.

(b) Bottom Seals. -Bottom seals on the top gate sections shall be of fabric reinforced synthetic rubber, clamped to the bottom of the gate sections by structural steel clamp bars and bolts of hot-rolled bar steel with tobin bronze and spring lock washers. Junction with the end seals shall be made with synthetic rubber blocks clamped and commpressed against the gate members and the bottom seal to form water-tight joints. Each synthetic rubber bottom seal between the end joints shall be in one piece and reinforecment shall be continuous to within 3/4 inch from the end. Both holes shall be accurately located from the holes in the gates, or from templates made from them, and shall be 1/16" smaller in diameter than the nominal diameter of the bolts.

Bottom sealing for the 25'-8" gates shall be by bearing of the planed steel surfaces of the gate on the babbitt metal in the sill.

5-05. DIVERSION GATE WATER SEALS. -The temporary water seals shall each consist of a circular section of tread stock rubber, continuous along the sides and bottom of each assembled diversion gate, and contained within the seal retaining slot of the temporary seal structure. The rubber seal shall be mitered and cemented at the corners to form a tight and secure joint. The rubber seal shall be backed by an air hose, also contained in the seal retainer slot, for the purpose of providing sealing pressure between the rubber seal and the face of the dam. A coupling for attaching an air supply line shall be furnished at one end of the hose and a cap at the other end.

5-06. DIVERSION GATE DOGGING ASSEMBLIES. -Dogs shall be alloy steel castings and shall have phosphor bronze bushings pressed in and doweled. Pins shall be alloy steel forgings, and shall be drilled, tapped, and grooved for grease pipe connections and for distribution of grease to the bushings. Push rods shall be black steel pipe, and minor fittings shall be carbon steel castings. Grease pipes shall be 3/8" O.D. annealed copper tubing with flared joint Marine & Refrigeration type fittings and shall be suitable for a cold oil working pressure of 2,000 lb. per sq. in. They shall be equipped with button-head type grease fittings of the same size as those on the gates and which shall be easily accessible from the tops of the piers. The details of the operating mechanisms shall allow independent operation of each dog and keep the pier nose tops clear above Elev. 250.33 in order to permit transporting the highest diversion gate along the dam. The design of the dogging assemblies shall be such that the dog castings and pins may be used as part of the permanent spillway gate dogging assemblies.

5-07. GREASE COMPRESSOR. -The Grease compressor shall be mounted on a suitable 2, 3, or 4-wheel pneumatic-tired chassis and the entire unit shall be easily transported along the deck by one man. Tires shall be of standard commerical size. The compressor unit shall consist of a single-phase electric motor for operation on 110-120 volts, an air compressor driven by the motor and grease reservoir of not less than 100 pounds capacity. A flexible grease line terminating in a valve and fitting for connection to the gate wheel lubrication systems, and long enough to reach from the upstream side of the roadway to the grease inlet on the lowest bottom gate section when the gate is closed, and to the grease inlet on any diversion gate section, shall lead from the grease reservoir. All parts of the system shall be suitable for handling the lubricant specified for the gate wheel lubrication systems. There shall be furnished, also, an air-operated grease gun for servicing the dogging

assemblies which shall have a grease capacity of not less than 5 pounds and which shall be equipped with an air hose with connection to the air compressor and necessary valves and fittings for connection to the grease inlets. The air hose shall be long enough to permit servicing the diversion gate dogging assemblies. The grease gun shall be suitable for handling the high pressure lubricant specified for bearings other than gate wheel bearings. A full complement of wrenches and any other small tools necessary for normal maintenance of the grease compressor shall be furnished with it. All parts of both grease systems shallbe suitable for a cold oil working pressure of 2,000 lbs. per sq. in. A heavy duty rubber-covered flexible cable 50 feet long with necessary fittings shall be provided for plugging in the motor at the electrical outlet on the dam. Suitable facilites shall be provided on the chassis for neatly stowing the grease hose, air hose and gun, tools and the power cable.

SECTION VI

WEDGE-OPERATING EQUIPMENT - ELECTRICAL

6-01. MOTORS. - Motors shall conform to the standards of the American Institute of Electrical Engineers and of the National Electric Manufacturers Association. They shall be six pole, 1/6 H.P., continuous rating, 440 volt, three phase, 60-cycle, squirrel cage induction motors, ratings according to the Standardization Rules of the A.I.E.E. They shall be totally inclosed and mounted approximately as shown in drawing BD-1-40/2.

6-02. LIMIT SWITCHES. - Adjustable limit switches shall be provided for both directions of travel, but other control equipment and wiring will be furnished by the Government. Spring stops for both directions of travel shall be provided such that the torque at the flexible coupling shown in the drawings will not be more than 400% of the rated torque of the motor when the motor is brought to a stop.

SECTION VII

MATERIALS

7-01. GENERAL.

(a) Materials. - All materials shall be of new unused stock, and free from defects. Substitution of size of sections and materials from that shown on the drawings or required in the specifications shall not be made except on written approval of the contracting officer and provided that the cost to the Government shall not be increased thereby.

Materials indicated on the drawings or required in the work and not covered elsewhere in these specifications by detailed requirements, shall conform to the requirements of this section.

Any materials required which are not covered by detailed specifications herein or elsewhere in the specifications shall conform to the applicable Federal Specifications, grade and/or class as required or, in case there are no applicable Federal Specifications, to applicable specifications of the American Society for Testing Materials (A.S.T.M.). In all other cases not specifically covered in these specifications the contractor shall furnish the highest grade commercial material or product.

(b) Inspection, Acceptance and Rejection of Materials. - All materials shall be subject at all times to inspection by the contracting officer who will select such samples in such quantities as he may deem necessary and subject the same to such tests as may be necessary to determine their qualities as herein specified, and he will accept or reject materials in accordance with the results of such tests. Tests may be repeated upon arrival of the various shipments at the site of the work as may be necessary to insure the acceptance of only such materials as will comply with the provisions of the plans and specifications.

(c) Test Specimens. - Special test specimens shall be furnished by the contractor on request; and shall be of such shape and number as designated; and shall in general conform to Federal Specifications or the specifications of the American Society for Testing Materials as to shape, size, and method of testing.

(d) Mill Test Reports. - Mill test reports certified to by qualified technicians shall be furnished when required for all material entering into this work and will, in general, be the basis of acceptance or rejection of the materials. The contracting officer may, however, require of the contractor special chemical or physical tests on any part of the material if in his opinion the conditions justify such a check.

(e) Federal Specifications. - Copies of Federal Specifications referred to herein may be procured from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a price of five or ten cents each. When the term: "Federal Specifications" or "A.S.T.M. Specifications" is cited, the reference shall be construed to mean the specifications as modified by an amendments promulgated before the date of opening bids for the contract.

7-02. STRUCTURAL CARBON STEEL. - Structural carbon steel shall conform to Federal Specification QQ-S-711a for "Steel, Structural; (for) Bridges", Class A. Surface imperfections shall be remedied by arc-welding and according to Government practice. The chemical properties of the steel shall be such as to permit it to be readily welded by this process.

7-03. RIVET STEEL. - Rivet steel shall conform to Federal Specification QQ-S-71la for "Steel, Structural; (for) Bridges", Class C.

7-04. STRUCTURAL SILICON STEEL. - Structural silicon steel shall conform to the standard Specification of the American Society for Testing Materials for "Structural Silicon Steel", Designation A 94-39.

7-05. COPPER-BEARING STEEL. - Copper-bearing steel sheets and plates shall conform to Federal Specification QQ-S-71la for "Steel, Structural; (for) Bridges" Class B.

7-06. ALLOY STEEL CASTINGS. - Alloy steel castings shall conform to the standard Specification of the A.S.T.M. for "Alloy Steel Castings for Structural Purposes", Designation A 148-36, Class B, Grade 2.

7-07. CARBON STEEL CASTINGS. - Carbon steel castings shall conform to Federal Specification QQ-S-68la, for "Steel; Castings", Class 2, except where shown otherwise on the drawings or called for in these specifications.

7-08. ALLOY-STEEL FORGINGS. - Alloy-steel forgings shall conform to Tentative Specifications of the A.S.T.M. for "Alloy-Steel Forgings for General Industrial Use", Designation A 237-40T, Class E.

7-09. CARBON-STEEL FORGINGS. - Carbon-steel forgings shall conform to the Tentative Specifications for "Carbon-Steel Forgings for General Industrial Use", Designation A 235-40T.

7-10. BOLTS AND NUTS.

(a) Unless otherwise specified or called for on the drawings, the material for bolts and nuts shall conform to the Standard Specification of the A.S.T.M. for "Commercial Quality Hot Rolled Bar Steels", Designation A 107-40, Grades 22, 23, 24, or 25.

(b) The material for bronze bolts and nuts shall conform to Federal Specifications QQ-B-636 for "Brass, Naval; Bars, Plates, Rods, Shapes, Sheets and strips", Type I, half hard.

(c) The material for bolts and nuts of "high strength steel" shall conform to the Tentative Specification of the A.S.T.M. for "Alloy-Steel forgings for General Industrial Use", Designation A 237-40T, Class D.

7-11. ROLLED STEEL WHEELS.

(a) The steel for the gate wheels shall conform to the Standard Specifications of the A.S.T.M. for "Multiple-wear Wrought Steel Wheels" Serial Designation A 57-39. The treads of the wheels shall be heat-treated to produce a Brinell hardness of 335 to 375. The plate and hub of the wheels may show no appreciable hardness over the untreated condition, but the heat-treating process shall be such as to avoid the setting-up of internal stresses in the plate of the wheel. The contractor shall furnish the contracting officer with certified copies of charts showing the process for each heat-treatment of wheel material.

(b) The contractor may submit an alternate proposal for wheel material which may be approved by the contracting officer, provided the physical characteristics are comparable to those of the material specified above.

7-12. ROLLER BEARING STEEL. - Steel for both rollers and races of the roller bearings shall conform to the Specifications of the Society of Automotive Engineers, S.A.E. number 52100, or approved equal.

7-13. DIVERSION GATE TRACK RAILS.

(a) These 175-pound rails shall be new and shall conform to the Standard Specifications of the A.S.T.M. for "Open-Hearth Steel Girder Rails of Plain, Grooved, and Guard Types", Designation A 2-27 for Class A, No. 1 rails with the following changes to sections thereof.

(1) Section 12(a). - The lengths of all rails shall be in accordance with the design drawings.

(2) Sections 12(b), 12(c), and 20(b). - These sections shall be ineffective.

(3) Section 16(a). - The diameter of all bolt holes shall not vary more than 1/32 inch over or under that specified.

(4) Section 16(b). - The location of all bolt holes shall not vary more than 1/32 inch either longitudinally or vertically from that specified.

(b) The length of 175 lb. track rails which are to be heat-treated shall be heated uniformly throughout their entire length and cross-section to above the critical temperature, quenched, and tempered to produce a Brinell hardness of 320 to 350. Heating, quenching, and tempering shall be done with equipment which will accommodate the entire length of each piece. After heat-treatment, all rails shall be smooth on the head, straight in line and surface, and without any twists, waves, or kinks.

7-14. SPLICE BARS. - All splice bars shall be new and shall conform to the Standard Specification of the American Society for Testing Materials for "Low-Carbon-Steel Joint Bars", Designation A 3-33, and shall be notched where necessary to clear rail clips.

7-15. RAIL CLIPS. - Rail clips shall be either structural steel, forged steel or cast steel, in accordance with the standard practice of the contractor, and shall be specially and accurately formed to permit the adjustment required in setting the rail.

7-16. COLD ROLLED STEEL. - Cold rolled steel shall conform to the Standard Specification of the A.S.T.M. for "Commercial Cold-Finished Bar Steels and Cold-Finished Shafting", Designation A 108-36, Grades 1 to 10.

7-17. ROLLED NICKEL STEEL. - Rolled nickel steel, unless otherwise specified, shall conform to the Standard Specification of the A.S.T.M. for "Carbon-Steel and Alloy-Steel Blooms, Billets, and Stubs for Forgings", Designation A 17-29, Type B, Alloy Steel, Grade 13, Class I, with chemical composition controlled as follows:

Carbon	0.25-0.35%
Nickel	3.25-3.75%
Manganese	0.50-0.80%

The steel shall be heat-treated to produce the most desirable physical properties. The yield point shall be not less than 65,000 lbs. per sq. in.

7-18. CORROSION-RESISTING STEEL. - Corrosion-resisting steel shall conform to Federal Specification QQ-S-763 for "Steel, Corrosion-Resisting; Bars and Forgings", Grade 6 with sulphur content of 0.18-0.35 percent with phosphorus .04 (max); and shall be free machining and suitable for threading and upsetting.

7-19. TOBIN BRONZE. - Tobin bronze shall conform to Federal Specification QQ-B-636 for "Brass, Naval; Bars, Plates, Rods, Shapes, Sheets, and Strips", Type I, half hard.

7-20. PHOSPHOR BRONZE. - Phosphor bronze for bushings, unless otherwise specified shall conform to Federal Specification QQ-B-691 for "Bronze; Castings", and shall be "Composition 10".

7-21. SELF-LUBRICATING BUSHINGS. - Self-lubricating bushings shall be of the bronze and insert type, Lubrite or equal.

7-22. BUTTON-HEAD GREASE FITTINGS. - Button-head grease fittings shall be of the giant industrial type, with 3/8" pipe threads, Alemite or equal.

7-23. SYNTHETIC RUBBER. - Synthetic rubber shall be "Neoprene" or equal. The composition of the tread stock shall be such as to produce a tensile strength of not less than 3,000 lbs. per sq. in., elasticity not less than 500%, and a durometer hardness of 60 to 67½. The composition of the cushion stock shall be such as to produce a tensile strength of not less than 2,000 lbs. per sq. in. elasticity not less than 700% and a durometer hardness of 35½ to 47.

7-24. RUBBER. - Rubber for the diversion gate seals shall meet the requirements for tread stock synthetic rubber (paragraph 7-23).

SECTION VIII - WORKMANSHIP

8-01. STRAIGHTENING, BENDING, SHEARING AND CUTTING.

(a) Structural materials shall be straightened in the shop, by methods that will not injure the metal, before being laid out or worked on in any way. Sharp kinks or bends shall be cause for rejection.

(b) Curved members shall be accurately pressed or rolled to the required curvature and attendant deformation of the section shall be prevented or corrected. Heating shall not be employed except with specific approval, and special precaution shall be taken to avoid overheating.

(c) Shearing, clipping, and cutting shall be done accurately and neatly and all exposed edges shall be smooth. Re-entrant cuts and copes shall be filleted before cutting. Sheared edges of plates more than 5/8" thick shall be planed to a depth of 1/4 inch. Where explicitly shown on approved shop drawings, structural shapes and plates may be cut by oxyacetylene flame directed by machine. No material shall be cut by the electric arc.

8-02. RIVET AND BOLT HOLES.

(a) Rivet holes in horizontal and end girders, in inner axle supports, and in vertical diaphragms at lifting device connections shall be punched or drilled at least 3/16" smaller than the nominal diameter of the rivet and reamed in assembly to a diameter 1/16" larger than the nominal diameter of the rivet, or shall be drilled full size in assembly. Holes in the skin plate, stiffeners, vertical diaphragms except as noted above, and minor parts may punched or drilled full size. If the thickness of the material is not greater than the diameter of the holes plus 1/16", the holes may be punched. In thicker material the holes shall be drilled. Finished holes shall be 1/16" larger than the nominal diameter of the rivets to be used in them. All holes shall be accurately spaced, cylindrical, and perpendicular to the member. All countersinking shall be true and square with the hole. In punching, the diameter of the die shall be not more than 3/32" larger than the diameter of the punch. All holes shall be clean cut without torn or ragged edges. All reaming and final drilling shall be done with the component parts of the member assembled and firmly clamped together. Drilling shall be done with twist drills. Reaming shall be done with short taper reamers.

(b) If holes are punched or drilled full size, the accuracy of spacing and alignment shall be such that when parts are assembled for riveting a cylindrical pin 1/16" smaller than the diameter of the hole shall pass through, perpendicular to the plane of the connection and without drifting, not less than 75% of any group of contiguous holes; and a cylindrical pin 1/8" smaller than the diameter of the hole shall pass through, perpendicular to the plane of the connection, 100% of any group of contiguous holes. Holes which require enlarging in order to pass the rivets shall be reamed.

(c) The accuracy of workmanship of holes reamed or drilled after assembly shall be such that at least 75% of any group of contiguous holes in the same plane shall show no offset greater than 1/32" between adjacent thickness of metal, except that holes for turned bolts shall be truly cylindrical throughout and within the limits and tolerances of the American Standards Association for Metal Fits, Class 4, Snug Fit. Wherever practicable, both drilling and finish reaming for turned bolts shall be done with the component

parts assembled and firmly clamped into position. If the foregoing procedure is impracticable, drilling of the separate parts shall be to template and the reaming done in assembly. After final punching, reaming or drilling, each hole shall be gone over with a satisfactory tool removing all burrs and sharp edges.

8-03. BOLTS AND NUTS.

(a) Except as otherwise specified or shown, all bolts, nuts, and studs shall conform to the American Standards Association requirements for semi-finished washer-faced, regular hexagon heads and heavy hexagon nuts, and shall have cut threads, coarse thread series, Class 3 fit.

(b) Turned bolts shall meet all requirements of the foregoing general specifications for bolts and nuts. In addition, the shanks shall be turned 1/16" larger in diameter than the nominal diameter of the thread, shall be truly cylindrical and within the limits and tolerance of the American Standard for Tolerance, Allowances and Gages for Metal Fits, Snug Fit, Class 4. The un-threaded portion of the bolt shank shall be 1/16" to 1/8" longer than the thickness of the connected members. Each bolt shall be provided with a steel washer 1/4" thick.

(c) Bolts for connection of machine parts, or other parts which are to be removable, including seals, shall have nuts of tobin bronze.

8-04. RIVETS AND RIVETING. - Rivets shall have a nominal diameter of at least 7/8" except as authorized by the contracting officer. The nominal diameter shall be the actual size of the cold rivets before heating. All connections shall be accurately and securely fitted up before the rivets are driven. Drifting done during assembling shall be only such as to bring the parts into position and not sufficient to enlarge the holes or distort the metal. Rivets shall be driven by direct-acting riveters where practicable and the riveters shall retain the pressure after the up-setting is completed. Where necessary to drive rivets with a pneumatic hammer, a pneumatic bucker shall be used for holding up where practicable. Rivets shall be heated uniformly to a light cherry-red color and driven while hot. They shall not be burned or over-heated. When heated and ready for driving they shall be free from slag, scale, and other adhering matter. When driven they shall completely fill the holes. Heads shall be of an approved shape, of full and equal sizes, free from fins, concentric with the shanks, shall have full contact with the surface of the member, and shall grip the assembled parts firmly together. Unless otherwise specified or authorized, counter-sunk rivets shall be chipped or ground flush. Loose, burned, badly formed, or otherwise defective rivets shall be replaced. In removing defective rivets care shall be taken not to injure the adjacent metal and, if necessary, they shall be drilled out. Calking or recupping of defective rivets will not be permitted. In any case when a cold rivet of the size specified cannot be entered with light tapping, the hole shall be reamed with a twist reamer.

8-05. WELDING.

(a) Welding will be permitted only where specifically called for on the drawings or authorized by the contracting officer. All welding shall be done by the electric arc method using a process which will exclude the atmosphere from the molten metal. The following requirements as to welding procedure apply specifically to hand welding. Machine welding processes and procedures will be permitted as specifically authorized by the contract-

ing officer. All welding except as otherwise specified shall be done in accordance with the applicable current Codes, Specifications, and Recommended Practices of the American Welding Society.

(b) Parts to be welded shall be rigidly held by sufficient clamps or other adequate means to keep the parts in close contact and in accurate position. Adequate precautions shall be taken to minimize locked-up stresses and distortion due to heat. Each pass of all welds shall be thoroughly peened while hot with a pneumatic tool for the purpose of relieving localized welding stresses.

(c) Fillet welds in sizes up to 1/4" shall be made in one pass, and larger welds shall be made in two or more passes. Successive beads or layers shall be uniform in thickness. Each layer of weld metal shall be thoroughly cleaned before subsequent layers are deposited. Upon completion, each weld shall be thoroughly cleaned and brushed with wire brushes, and extraneous nodules of weld metal shall be removed by chipping.

(d) Wherever there is danger of the assembled structure or member becoming warped or distorted by localized welding stresses, the welds shall be thoroughly peened with a pneumatic tool to relieve such stresses. Peening for this purpose shall be done wherever directed by the contracting officer.

(e) All welds shall be free from unsound metal, cracks, overlap, and feather edges. Minor imperfections in welds may be chipped out and the defect rewelded, subject to approval. Distortions due to welding or stress-relieving shall be corrected by pressing and not by blows.

(f) Welding shall be done only by welders properly qualified in the work of the actual process employed. The contractor shall assign to each welder an identifying number, letter or symbol, which shall be stamped in the metal adjacent to end at intervals of not more than three feet along all welds which he makes. Before beginning the production of welded work, the contractor shall furnish to the contracting officer satisfactory evidence, in the form of a certificate by a recognized testing agency or by actual demonstration, that each welder to be employed on the work of this contract has within one year of the date of the contract satisfactorily performed the qualification tests prescribed by the American Welding Society in its "Code for Fusion Welding and Gas Cutting in Building Construction" (Latest Edition), using the detailed procedure to be followed in actual production under this contract. Expense of any tests necessarily performed under this provision shall be borne by the contractor. The contractor shall require any welder to repeat these tests when the opinion of the contracting officer the work indicates a reasonable doubt of the welder's efficiency.

8-06. GIRDER END CONNECTIONS AND STIFFENERS.

(a) The end connection angles of all horizontal girders shall be fitted to a bearing against the flanges of the girders. The faces of the outstanding legs of the connection angles shall be milled to a true bearing against the webs of the vertical end girders and sufficient extra thickness of connection angles shall be allowed for milling.

(b) Stiffeners need not bear against the flange angles but shall fit within 1/32".

8-07. CASTINGS. - The design of all castings shall be such as to minimize cooling stresses. Unfinished edges, ribs, and similar parts shall be cast with rounded corners and all inside angles shall have ample fillets. All bolt heads and nuts shall bear on finished seats at 90 degrees to the

axis of the bolts. All Castings shall be cleaned and fins and other irregularities removed. Castings to be attached to structural steel work shall have contact surfaces finished. Other surfaces shall be finished where indicated by good practice and by the design of the structure or device of which the casting is a part.

8-08. RAILS.

(a) Rails shall be straight in line, without twists, waves or kinks, and shall be smooth on the heads. Ends shall be milled square and the rails matched for height at the splices. If necessary to secure a smooth joint the heads may be machined 3" back from the splice. After matching, the rails shall be match-marked to insure assembly of the proper pieces in the field. Flame cutting of rails will be permitted, if machine guided, and provided 1/8" stock is left on material for finishing.

(b) Rail fittings shall not interfere with the free entrance or movement of the gate.

8-09. SHOP ASSEMBLY AND PREPARATION FOR SHIPMENT.

(a) The gate sections which are completely shop fabricated shall have all equipment properly attached and adjusted in the shop, after which the seals and any other parts or equipment, liable to damage in shipment shall be removed, marked to identify them with the proper gate section and boxed or crated to protect them from damage in transit. Wheels shall be aligned and axle lugs attached, greasing systems connected and filled with grease, and lifting and coupling devices installed, wedged and blocked to prevent movement or damage.

(b) The gate sections which are to be spliced in the field shall be completely assembled in the shop with holes for field connections reamed and bolted with turned bolts and with wheel assemblies, seals, heaters, and lifting and coupling devices in place. After inspection and approval by the authorized representative of the contracting officer, the spliced parts shall be marked for identification and the gate section taken apart for shipping. Each wheel assembly and each lifting and coupling device, with all connections and accessories, shall be individually boxed and marked for identification as well as seals, lubrication pipes and fittings, and any other parts liable to damage in transit. The lifting beam shall be completely shop-fabricated and shipped in one piece with the lifting and coupling devices wedged and blocked to prevent movement or damage.

(c) Each dogging assembly shall be completely assembled in the shop and, after inspection and approval, the pieces shall be marked or tagged for field assembly and pieces liable to damage during transit boxed or crated.

(d) Track rails shall have splices assembled in the shop and the spliced pieces match-marked for field assembly. Bolts, studs, pipe sleeves, clips, splice bars, and other small parts shall be boxed for shipment.

(e) Each box or crate shall contain all parts necessary for field connection of the equipment contained in it and shall have a list inclosed showing the entire contents.

(f) All marks shall be in accordance with approved assembly drawings, shall be clearly legible and so placed as to be visible when the part is being erected in the field. Each piece weighing more than one ton shall have the approximate weight marked thereon. Connecting parts assembled in the shop shall, before dismantling for shipment, be match-marked to facilitate

field erection.

(g) The contractor shall prepare all materials and articles for shipment in such manner as to facilitate handling and to protect them from damage in transit and shall be responsible for and make good any and all damage due to improper preparation and loading for shipment. All threads and finished surfaces shall be protected as specified in Section IX.

8-10. TOLERANCES AND FITS.

(a) General. - Fits shall be in accordance with applicable requirements of the American Standards Association for Metal Fits.

(b) Gates and Lifting Beam. - The overall width of any gate section as represented by the distance between outside faces of the vertical end girder web plates measured at any point in the height of a gate section shall not vary from that called for on the drawings by more than 1/8" plus or minus. In an individual gate section, the maximum horizontal distance between outside faces of the vertical end girder webs shall not exceed the minimum by more than 1/8". The vertical end girder webs shall be straight and perpendicular to the skin plate.

The overall height of any gate section shall be as called for on the drawings with a tolerance of 1/4" plus or minus.

Each gate section shall be truly rectangular within the limits imposed by the tolerances permitted above.

The outside surface of the skin plate of each gate section shall be a true plane with a tolerance of 1/4" plus or minus, which tolerance shall include the standard mill variation in plate thickness.

The axis through the centers of each pair of wheel axle holes on a gate section shall be at 90 degrees to a plane perpendicular to the skin plate and containing the vertical center line of the gate, with a tolerance not exceeding no degrees, three minutes, thirty seconds (0° 3' 30") in any direction. All axle holes shall be on the "Wheel Center Line" as shown on the drawings with a tolerance of 0.020" either way.

The accuracy of workmanship shall be such that when the wheels are aligned, the distance from the contact surfaces of the wheel treads to the face of the vertical seal support shall not vary from the nominal dimension by more than 1/8" plus or minus.

The distance from the outer face of the vertical end girder web plate to the outer face of the support for the inner end of the axle at any wheel shall not vary from the nominal dimension by more than 1/64" plus or minus. The face of the support shall be spot-faced at the axle hole to furnish a bearing seat for the shoulder on the inner end of the axle.

Axle holes in both the end girder and in the inner axle support shall have free fit on the axle. Wheels shall be truly circular at the tread. The tread diameter shall be 30" with tolerance of 0.01" plus or minus. The flange diameter shall be 32" with a tolerance of 1/16" plus or minus. Wheel treads shall be $4\frac{1}{2}$" wide with a tolerance of 0.005" plus or minus. Contour of the tread and flanges shall be suitable for use on the 175-pound crane rail used for the gate track. The distance from the center of the wheel tread to the outside of the hub cover shall be not greater than 5-3/4"; and to the outside of the bearing seal cover not greater than $5\frac{1}{2}$".

Holding bolts for the bearing seal and hub covers shall have free fit in the holes. The position of the centers of the lifting hooks and coupling devices on any gate section shall not vary more than 1/8" plus or minus from their nominal position as measured from the vertical center line

of the gate or more than 1/16" plus or minus from their nominal position as measured from the downstream face of the skin plate. The position of the coupling devices on the lifting beam shall be on the longitudinal center line within 1/16" in either direction and shall not vary more than 1/8" plus or minus, from the nominal position as measured from the center line of the beam.

Guide pins shall have sufficient taper to enter the guide sockets with ample clearance while the gate sections, or gate section and lifting beam, are at the maximum limits of their sidewise movements in opposite directions; and shall have close enough clearance when entered to center the gate sections, or the gate section and lifting beam, and allow the coupling device to operate freely.

SECTION IX - PAINTS AND PAINTING

9-01. GENERAL. - Unless otherwise specified or authorized, all paint materials shall conform to the current Federal specifications wherever applicable. Where Federal specifications are not applicable, material shall be as specified, or otherwise subject to the approval of the contracting officer. All paint, when applied, shall provide a satisfactory film and a smooth even surface, except when sand reinforced, and undercoats shall dry without excessive gloss, suitable for the proper application and adhesion of subsequent coats, as approved by the contracting officer. Where necessary, in the opinion of the contracting officer, to suit the conditions of surface, temperature, and weather existing at the particular time of application, the packaged paint may be thinned by the addition of not more than one pint per gallon of mineral spirits immediately prior to application, provided that in no case shall the viscosity of the paint be reduced to a point where the specified maximum coverages will be exceeded.

9-02. SURFACE CLEANING AND PREPARATION.

(a) Cleaning. All ferrous surfaces to be painted shall be thoroughly cleaned of all millscale and other foreign substances to base metal by sandblasting or any other method approved by the contracting officer.

(b) Protection of Surfaces. Care shall be taken to adequately protect all machinery parts, threads, and finished surfaces during cleaning and preparation.

(c) Inhibition. All surfaces cleaned by sandblasting or equally effective method, shall be treated with a chemical rust inhibitor (paragraph 9-06). As soon after cleaning as practicable, and prior to formation of any forms of corrosion from atmospheric moisture, or other causes, the inhibitor shall be applied by brush and permitted to dry. This chemical inhibitor however, shall be applied only under conditions such that the temperature of the surfaces to which applied and the air in contact therewith, are between 50 degrees F. and 110 degrees F. in order to insure proper chemical reaction with the metal. After drying, any unneutralized reactive residue on the surfaces shall be removed by thorough wiping with wet cloths and the surfaces redried. The inhibited surfaces shall be thoroughly brushed with a broom to remove the dry dusty reaction product and be given a standard priming coat of paint, as indicated, as soon thereafter as practicable, but in any event prior to deterioration or destruction of the inhibited surface. Should the inhibited surface be damaged or destroyed at any point by any means whatsoever the surfaces shall be cleaned and retreated in approved manner prior to application of the paint.

9-03. PAINT APPLICATION.

(a) All painting shall be done in a neat, thorough, and workmanlike manner. Except where otherwise specified or specifically directed, all paint coats shall be applied by either brush or spray in such manner as to produce an even coating of uniform thickness completely coating all corners and crevices. All painting shall be done by thoroughly experienced workmen. Care shall be exercised during spraying to hold the nozzle sufficiently close to the surfaces being painted to avoid excessive evaporation of the volatile constituents and loss of material into the air. Paint shall be applied only to surfaces that are thoroughly dry and only under such combination of humidity and temperatures of the atmosphere and surfaces to be painted as will cause evaporation rather than condensation. A practical test is to wipe a damp cloth on the surface to

be painted. If the moist streak dries promptly, conditions conducive to evaporation prevail. In no cases shall any paint be applied to surfaces upon which there is frost or moisture condensation, or during rainy or misty weather, without suitable protection as approved by the contracting officer. Painting during unfavorable weather conditions shall be carried on under a protective covering. While any painting is being done, the temperature of the surfaces to be painted and of the atmosphere in contact therewith shall be maintained at or above 50 degrees F. All paint when applied shall be approximately (within fifteen degrees of) the temperature as that of the surface on which it is applied. Where protection is provided for paint surfaces, such protection shall be preserved in place until the paint film has properly dried and removal of the protection is authorized by the contracting officer. Working parts, hardware, and other surfaces not required to be painted shall be cleaned and protected to the satisfaction of the contracting officer.

(b) Coverage. - The surface area covered per gallon for each type of paint specified shall be not greater than 425 square feet per gallon.

9-04. PRIMING COATS.

(a) Unpainted Surfaces. - Non-ferrous metal-coated surfaces machined surfaces, surfaces requiring welding, and surfaces which will be in riveted contact shall not be painted. All other ferrous surfaces, unless otherwise specified shall receive one priming coat of Synthetic Red Lead Primer.

(b) Structural Parts shall receive one shop priming coat.

(c) Spillway Gates shall be painted with two shop coats of primer.

(d) Machinery and Mechanical Equipment (except threads and finished surfaces) shall receive one shop-priming coat.

(e) Exterior Electrical Equipment shall receive one shop-priming coat, except that enclosing cabinets and cases shall be given two shop-priming coats on the inside and one shop-priming coat on the outside. All cast metal surfaces requiring painting shall be smoothly finished with an approved filler prior to the application of paint.

(f) Machines Surfaces shall immediately after final inspection be thoroughly cleaned of all foreign matter and coated with a heavy film of Rust Preventive Compound, U. S. Army Specification 2-84A.

(g) Screw Threads shall be protected by a coating of heavy oil.

9-05. PAINTS AND PAINT FORMULAE. -

(a) General. - Paints shall have the composition as indicated below or as otherwise approved by the contracting officer. All paints shall be guaranteed by the manufacturer not to gel, liver, or thicken deleteriously or form gas in a closed container within a period of one year from date of manufacture.

(b) Processing of Paints.

(1) Except where otherwise specified or authorized, all paint shall be made by grinding together dry or paste pigments and a liquid vehicle to form a smooth paint that will flow freely and will not settle or react deleteriously in containers.

(2) Grinding shall produce a fineness such that coarse particles and skins will not exceed 1.5 percent (total residue left on No. 325 mesh screen, based on pigment). The grinding shall be done on a roll or pebble mill at temperatures that will not cause polymerization.

(3) Skinning shall be negligible after exposing 6 ounces of paint in a tightly closed 8-ounce glass container to sunlight for a total time of 24 hours.

(4) The resulting paint shall have satisfactory brushing and leveling properties, shall set to touch in not less than one hour nor more than four hours, unless otherwise specified, and shall provide a satisfactory film and a smooth even surface without undue gloss, suitable for proper application and adhesion of subsequent paint coats, as approved by the contracting officer. Sufficient suitable driers shall be added to make the paint dry hard within 18 hours.

(5) In view of potential variations resulting from variable processing equipment and technique, the manufacturer may be allowed, where necessary to produce the specified viscosities, to make slight changes in formula proportions, subject to specific approval of the contracting officer.

(c) Synthetic Red Lead Primer shall be composed of materials conforming, where applicable, to the specified requirements and mixed in the proportions as follows:

Read Lead	16.5% by weight
Iron Oxide	38.2%
Zinc Yellow	5.5%
Diatomaceous Silica	6.0%
Vehicle (see par. 9-07)	28.0%
Thinner	5.8%

The paint shall have a consistency of flow of between 25 and 40 seconds through the 0.15 inch diameter orifice of a standard consistency cup when tested in accordance with the procedure specified in paragraphs 9 and 10 of A.S.T.M., Specification D 333-37 for "Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels." It shall have satisfactory brushing and leveling properties, shall set to light touch in not less than 2 hours nor more than 5 hours, and shall dry hard for recoating in not more than 18 hours, when tested in accordance with paragraph P-2d of Federal Specification TT-V 81a, entitled "Varnish; Mixing (for) Aluminum Paint." The vehicle shall be a synthetic resin varnish consisting of aphenol formaldehyde resin with the necessary oils and volatile thinners to produce elasticity, water-proofness, adherence, and durability in the finished paint film. It shall meet the detailed requirements of paragraph 9-07.

9-06. CHEMICAL RUST INHIBITOR, to be used where specified or required, shall be an approved compound of water, a wetting agent, a viscosity agent, phosphoric acid, and sodium dichromate. The concentration of the solution at the time of application shall be such that the Orthophosphoric acid (H_3PO_4) content shall be between 7.0 and 9.0 percent (by weight) and the Sodium Dichromate approximately 0.75 percent. Commercial chemical rust inhibitors of composition somewhat different from this may be acceptable in lieu thereof, subject to approval by the contracting office of results of approved tests showing that the inhibitor, when applied in accordance with instructions of the manufacturer, will identically affect ferrous surfaces as the specified compound in the following ways:

(a) Chemically react with rust and surface metal to etch the surface, form a dull grayish coating of iron-chromate-phosphate, and produce a rush-inhibited surface receptive to the firm bonding of the priming paint.

(b) After initially being thoroughly dried, the inhibited surface shall show no deleterious rusting when subjected to light rain or to other

dampening agency for a period of not less than 4 hours.

(c) Leave no unneutralized active chemicals on the surface.

9-07. PHENOLIC RESIN VARNISH VEHICLE shall conform to the following requirements:

(a) Oil-resin ratio shall be 33 gallons of oil to 100 pounds of resin.

(b) Shall be clear and transparent and entirely free from resin, estergum, or other non-phenolic resins. Not less than 50 percent by weight of the vehicle shall consist of non-volatile oil and resin.

(c) The resin content shall be 100 percent para-phenyl phenoform-aldehyde condensate similar and equal to Bakelite BR 254, and shall conform to the current U. S. Navy Department Specification 52R10 entitled "Resin-Phenol-Formaldehyde."

(d) The volatile thinner shall contain not more than 80 percent mineral spirits and not less than 20 percent high flash coal tar naphtha or high flash hydrogenated petroleum naphtha and shall be free from oxic hydrocarbons such as benzol.

(e) The oil content shall be a ternary oil mixture composed of 40% linseed, 30% liquid oiticica, and 30% "dehydrated" castor oil.

(f) The flash point shall be not below 30 degrees C. in a closed cup tester.

(g) Shall pass a Kauri Reduction Test of 120 percent, using the method described in paragraph F-2g, Federal Specification TT-V-81, for "Varnish; Mixing (for) Aluminum Paint."

(h) Shall show no skinning after 48 hours in a 3/4 filled, tight container.

(i) Flow-out films on tin plate panels dried 72 hours shall withstand immersion in cold water for 96 hours, and in distilled water at 200 degrees F. for 7 hours without showing more than a slight haze which shall disappear within one hour, and shall show no other signs of deterioration. The panel shall be allowed to dry and cool for 15 minutes after removal from hot water and shall then be inspected for signs of failure.

9-08. PIGMENTS.

(a) Carbon Black shall conform to either Federal Specification TT-B-601, entitled "Boneblack; Dry, Paste-in-Japan, Paste-in Oil" or Federal Specification TT-L-71 entitled "Lampblack; Dry, Paste-in-Japan, Paste-in-Oil."

(b) Lead Titanante shall be similar and equal to Titanox "L" as manufactured by the Titanium Pigment Corporation.

(c) Red Lead shall conform to Federal Specification TT-R-191a (97) percent Grade for "Red Lead; Dry and Paste-in-Oil."

(d) Iron Oxide shall contain not less than 98 percent Fe_2O_3 and shall not contain any organic coloring matter.

(e) Diatomaceous Silica shall be an approved commercial grade.

(f) Zinc Yellow shall contain not less than 40 percent CrO_3. It shall be a basic zinc potassium chromate, soluble in acetic acid, free from lead compounds, and containing no added zinc oxide, and shall be stable or non-reactive with the pigments and vehicles specified.

(g) Titanium Dioxide shall be similar and equal to either "Ti-Pure O" as manufactured by Krebs Pigment & Color Corporation or "Titanox NC" as manufactured by the Titanium Pigment Corporation.

9-09. THINNERS AND SOLVENTS.

(a) Mineral Spirits shall have the following properties:

Gravity - - - - - - - - - - - - - - - - 43-47 degrees Baume

Flash Point (Closed cup) - - - - - - - -100 degrees F. Min.

Initial Boiling Point - - - - - - - - - 300-310 degrees F.

End Point - - - - - - - - - - - - - - - 405 degrees F. Max.

A.S.T.M. Copper Strip Test - - - - - - -Negative

Solvency (Kauri-Butanol) - - - - - - - -41 cc (a) 77 deg. F. Min.

(b) Dipentine shall have the following properties:

	Maximum	Minimum
Specific Gravity at 15.5 deg. C.	0.854	0.845
Refractive Index at 20 deg. C.	1.477	1.472
Unpolymerized Residue (percent) (38N H_2SO_4	2.5	

A. S. T. M. Distillation Range:

5% Distilling at - - - - - - - - - - - - 173 degrees C.
10% Distilling at - - - - - - - - - - - - 175 degrees C.
97% Distilling at - - - - - - - - - - - - 188 degrees C.

Color-Lovibond 500 Amber - - - - - - - - - - 3
Appearance: Clear and free from suspended matter.

(c) Toluol shall conform to U. S. Navy Department Specification 52T7 entitled "Toluene (Toluol)", except that it shall have a solvency (Kauri-Butanol Method) of not less than 100 cc. at 77 degrees F.

(d) Xylol shall conform to A.S.T.M. Specification D364-36 for "Industrial Xylene (Xylol) or 'Solvent Naphtha'", except that it shall have a solvency (Kauri-Butanol Method) of less than 93 cc. at 77 degrees F.

(e) Normal Butyl Alcohol (Butanol) shall conform to A.S.T.M. Specification D304-33 for "Butanol (Normal Butyl Alcohol)."

(f) Ethylene Glycol Monoethyl Ether shall conform to A.S.T.M. Specification D331-35 for "Ethylene Glycol Monoethyl Ether."

9-10. MISCELLANEOUS MATERIALS.

(a) Oil, Linseed shall conform to Federal Specifications JJJ-O-331 for "Oil; Linseed, Boiled", or JJJ-O-336, for "Oil; Linseed, Raw", as specified or required.

(b) Insulating Varnish, U. S. Navy Department Specification 52-V-13b, entitled "Varnish; Insulating, (for) Electrical Purposes."

(c) Creosote Paint for surface treatment of timber shall conform to Federal Specification TT-W-561a, entitled "Wood-Preservative: Creosote (for) Brush and Spray Treatment."

(d) Ortho-Phosphoric Acid (H_3PO_4), shall be commercially pure

product, in liquid form, containing not less than 75 percent H_3PO_4.

(e) Sodium Dichromate, $Na_2Cr_2O_7 \cdot 2H_2O$) shall be a commercially pure product in crystalline form containing not less than 85 percent $Na_2Cr_2O_7$.

9-11. INSPECTION. -

(a) Unless otherwise specifically authorized, inspection of all materials for the paints and chemical rust inhibitor and the manufacture thereof, will be made by a representative of the contracting officer. All samples of materials and of the finished processed products will be tested and analyzed for conformity with the specifications by the Government. The inspector will collect for testing, samples of each of the materials to be used in the manufacturing processes and will then seal the material containers until test results from the samples indicate that the various materials conform to specifications. He will witness the breaking of the seals on the approved material containers and the compounding of the materials for the product being manufactured, will collect samples of the finished product for testing, and will witness the placing, sealing, and labeling of the finished product in containers for shipment. After the finished products have successfully passed the prescribed test, shipment of the sealed containers will be authorized.

(b) In the case of ready-mixed and packaged paints of standard manufacture, other than those specified by trade name, the contractor shall furnish a sample in the standard stock package, together with a certified copy of the complete chemical analysis, for test and approval by the contracting officer.

9-12. PAYMENT for all paint and painting will be included in the contract price for the respective metals or items painted.

SECTION X

INSPECTION AND TESTS

10-01. GENERAL.

(a) No item of equipment for which operation tests are herein specified shall be shipped from its assembly point until such tests have been satisfactorily performed in the presence of a representative of the contracting officer; or until specific authorization is made for the tests to be performed elsewhere.

(b) The contractor shall, at his own expense, furnish all material, equipment, and labor necessary for the tests and shall, when requested, furnish certified test reports to the contracting officer.

(c) The acceptance of any item of equipment shall not relieve the contractor of his responsibility for meeting all of the requirements of the specifications and shall not prevent subsequent rejection if such equipment is later found to be defective.

10-02. TESTS OF WHEELS

(a) Each wheel and axle shall be assembled complete with bearings and accessories, but without grease, and set up on a suitable support so that the wheel may be revolved on the axle. The wheels shall turn freely, consistent with the size and weight of the parts, and any indication of binding or excessive play shall be corrected. A dial indicator applied to the tread of the wheel when it is revolved shall indicate not more than 0.005 inch variation in a complete revolution of the wheel.

(b) Before assembling any of the wheels with the gates the contractor shall test one set of four wheel assemblies on a single special test axle, under both static condition and at a shaft speed of one-half revolution per minute for a period of four hours, under simultaneous test loads of 100,000 pounds, applied axially at a point near the wheel tread and 300,000 pounds applied radially. If any of the wheels, bearings, or other parts of the wheel assemblies fail to meet the requirements of these specifications under this test, the contracting officer or his representative may reject all of the affected parts, or order the test repeated such number of times as he deems necessary for him to determine the disposition to be made of such parts.

(c) The contractor shall test at least one finished roller bearing from each heat for ultimate strength. Failure of any roller to meet the requirements of paragraph 5-03 will be cause for rejection of all rollers made from the same heat or furnace charge.

(d) The contractor shall test one wheel assembly for tightness of gaskets and bearing seals with external atmospheric pressure and sustained internal pressure of 2.5 pounds per square inch absolute. Contact surfaces between seals and shafts may be greased or wet for this test. Rise in internal pressure due to leaks shall not exceed one pound per square inch in two hours.

(e) These tests may be omitted upon specific waiver by the contracting officer, provided the contractor submits satisfactory evidence that the wheel assemblies he proposes to furnish have successfully withstood tests of

a similar nature both as to magnitude of test loads and in the manner of their application.

10-03. TESTS OF GATES FOR WATERTIGHTNESS.

(a) Each gate section shall be tested in the shop after fabrication, and before applying rust inhibitor or paint, to demonstrate that all joints, connections and members are watertight at points where watertightness is required. This test shall be performed by coating the parts of the gate section which normally are to be in contact with headwater with a heavy-bodied compound of soap and water, and directing a jet of air at approximately 50 pounds per square inch pressure against the opposite faces at the required points. The parts which are coated with soap and water shall be inspected for air bubbles indicating points of leakage and any leaks so discovered shall be sealed by such permanent methods as their location may require.

(b) The contractor will be permitted to employ other methods of equal or greater efficacy in making this test, subject to the approval of the contracting officer.

10-04. TESTS OF LIFTING AND COUPLING DEVICES. -

(a) The complete assembly of the lifting and coupling devices for each end of each gate, shall be subjected to a proof tension test of 300,000 pounds with the loads applied at the upper hook and at the hook links as they would be applied during operation. Each whole assembly shall also be tested in tension to 150,000 pounds with the loads applied at the hook links and at the ends of the wedge in place in the slot in the upper hook. The position of the parts during the tests shall be the same as they would be if installed in the gate. After the tension tests the devices shall be installed in the gate. After the tension tests the devices shall be installed in the gates and tested for satisfactory operation under simulated operating conditions. Any permanent deformation due to the test loads shall not be great enough to affect the simultaneous operation of the devices or to appreciably reduce proper clearances.

(b) Each lifting hook and pin of the full depth gate sections shall also be tested in tension of 300,000 pounds with loads applied as they would be applied during operation.

(c) The lifting and coupling device in each end of the lifting beam shall be tested similarly with a load of 300,000 pounds.

10-05. TESTS OF DOGS. - Each diversion gate dog shall be mounted on its pin in a manner simulating operating conditions and tested separately with a load of 300,000 pounds applied at the seat.

LONG SAULT DAM

Specifications

For

GANTRY CRANE

SECTION II - DESCRIPTION

2-01. EQUIPMENT REQUIRED. - The equipment required under this contract consists of:

(a) One electrically operated gantry crane, with gasoline-electric auxiliary power, designated "Crane No. 1" on the drawings. "Crane No. 2" is not required under this contract.

(b) All tools, accessories and other equipment required for the operation and maintenance of the crane.

(c) One set of two lifting extensions, each approximately 27 feet long, for temporary use between the lifting beam and the lifting hooks on the diversion gates.

2-02. OPERATION.

(a) Temporary Operation. - The gantry crane will operate temporarily only on the part of the runway from the south end to the center line of pier P-14 and will be used primarily for the operation of the river diversion gates. Operation of these gates will involve raising or lowering them under full hydrostatic head with water surface at the top of the gates, and transportation of the gates along the upstream face of the dam. The gates will be handled by means of a lifting beam, furnished by the Government, which will contain a mechanism at each end so designed that the crane operator may connect the beam to or disconnect it from the lifting hooks on the gates. For this service the trolley will be run out on the cantilevered upstream projection of the trolley runway, and the trolley design must be such that all permanently attached parts will clear the upper sill of the upstream side frame of the gantry structure. When the gate tops are below about Elev. 229, temporary lifting extensions between the beam and the gate hooks will be used.

The crane will also be used for any service for which it is suited in the construction of the dam.

(b) Permanent Operation. - After the completion of the spillway, the gantry crane will be used for operation of the spillway gates in the slots between the upstream crane rail and the roadway, for transporting the gates along the dam, for handling the fixed gate hoists which will be erected over spillway openings 21 and 38 inclusive, and for miscellaneous service on the dam. The bumpers on the trolley runway will be shifted downstream from their temporary location as shown on the drawings in order to prevent running the trolley past the extreme upstream position for permanent operation. The lifting beam will be attached to the crane sheaves for operation of the gates, but will be removed for handling the gate hoists.

SECTION III - DESIGN

3-01. GENERAL. - The contractor shall assume full responsibility for a coordinated and adequate design fulfilling the requirements of these specifications and conforming to the best engineering practice. The design and construction shall conform to all usual safety requirements and safety guards shall be provided where necessary for the protection of operators or others from injury.

3-02. EXTERIOR APPEARANCE. - The exterior appearance of the crane shall be as nearly as practicable as shown on the drawings. The sections of members and details of framing shall be such that all external surfaces shall be smooth in appearance and free from exposed structural shapes and castings. Where this result cannot be conveniently attained, removable copper-bearing sheet steel covering not less than 1/8" thick shall be provided. All members, including box girders, shall be designed so that inside surfaces may be inspected, cleaned and painted; and access holes with flush covers shall be provided where necessary.

3-03. FRAMING. - The structural frame shall be rectangular in plan with each truck skewed at a fixed angle with the sill and with its center line tangent to the curve of the gantry track rail at the center of the portal leg. The portals spanning between the gantry rails shall be designed as rigid frames and shall have sufficient clearance at all points to clear the top of the fixed hoists and also clear the gates when they are dogged in the highest position in the emergency slots. The side frames shall consist of upper and lower sills with bracing as shown on the drawings and the cab shall be mounted inside the downstream bracing. The horizontal frame at the upper sills and the connections between the portal legs and the horizontal girders shall be adequately braced and gussetted to meet conditions of paragraph 3-05 (a).

3-04. CAPACITIES AND SPEEDS.

(a) Main Hoist. - The main hoist shall have a nominal capacity at the lower sheaves (on two drums) of 260 tons, with a hoisting speed of 2 feet per minute and with the trolley stationary. The maximum estimated load which the trolley will be required to transport on the trolley runway is 130 tons.

(b) Auxiliary Hoist. - The auxiliary hoist shall have a nominal capacity of 10 tons with a hoisting speed of 15 feet per minute.

(c) Gantry and Trolley Travel. - The gantry travel speed shall be 75 feet per minute and the trolley travel speed shall be 15 feet per minute. The gantry travel motors shall have such capacity that the crane, when loaded with a gate weighing 130 tons (including the lifting beam), may be used to tow a similar crane similarly loaded a distance of 1000 feet against a wind pressure of 10 pounds per square foot with a temperature rise of any motor not exceeding 50°F.

3-05. LOADS.

(a) General.- All parts of the crane shall be designed to sus-

tain the combinations, listed under 3-05(b) & (c) below, of the following loads with due allowance for eccentricity and without exceeding the unit stresses hereinafter specified:

(1) The dead load shall include the weight of the gantry structure and the trolley and all permanently attached mechanical and electrical parts.

(2) The design live load for the trolley shall include the rated load of 260 tons, the dynamic forces of acceleration and retardation, and tension in moving ropes. For the live load on the gantry structure, the following loads shall be considered:

a. The design live load on the trolley plus the weight of the trolley at the extreme upstream position on the cantilever arm.

b. The weight of the trolley with a load of 130 tons as a moving load at any point between the limits shown on the crane drawings for permanent gate operation.

c. The weight of the trolley with a lifting load of 175 tons plus the dynamic forces of acceleration and retardation and tension in moving ropes with the trolley over either gate slot. Impact allowance for live loads shall be 25%.

(3) The trolley tractive force shall be taken as 10% of the weight of the trolley with a load of 130 tons, and shall be considered as applied at the top of the trolley rails.

(4) The gantry bridge tractive force shall be taken as 10% of the weight of the entire loaded crane, which shall include the trolley, and a suspended load of 225 tons on the cantilever arm or a suspended load of 130 tons at any point between the limits for permanent gate operation. For the condition of the load on the cantilever arm, the entire tractive force shall be considered as resisted by the side frame on the upstream side of the crane. For the permanent gate operating condition, the tractive force shall be considered as distributed in the ratio of 3/4 to the downstream side frame and 1/4 to the upstream side frame.

(5) The wind load shall be considered as acting on the projected area of the crane structure and the suspended load. The wind area of the spillway gate shall be taken as 1350 square feet for wind acting normal to the gantry track and 130 square feet for wind acting parallel to the gantry track. The center of pressure of the wind on the suspended load shall be assumed at 17 feet above the upstream rail. The wind area of the diversion gate shall be taken as 2200 square feet for wind acting normal to the gantry track and 215 square feet for wind acting parallel to the gantry track. The entire wind load on the suspended diversion gate shall be assumed as transferred to the tops of the trolley rails. The wind intensity shall be taken as given in the various load combination specified below.

(6) The live load on the roof of the trolley runway housing shall be assumed as 35 pounds per square foot.

(7) The live load on floors and platforms shall be assumed as 50 pounds per square foot.

(b) Load Combinations - Permanent Gate Operation. - The following load combinations shall be considered for permanent operation of the crane with the trolley operating only within the range shown for "permanent gate operation" shown on the drawings.

Case I: For the gantry in operating condition, a wind load of 10 pounds per square foot in combination with dead and live loads, impact and traction forces.

Case II: For the gantry in static condition, a wind load of 30 pounds per square foot in combination with dead and live loads.

Case III: For the gantry in operating condition, a combination of dead and live loads and the forces produced by collision with the track stops with the loaded gantry traveling at full speed with power off.

Case IV: For the gantry in operating condition, a combination of dead load and the forces produced by the rated break-down torque of the hoist motor acting through one drum only.

Case V: For the gantry in static condition, a wind load of 40 pounds per square foot in combination with dead load only.

(c) Load combinations - Diversion Gate Operation. - The following load combinations shall be considered for operation of the river diversion gates with the trolley in the extreme upstream position shown on the drawings:

Case VI: Same as Case I
Case VII: Same as Case III
Case VIII: Same as Case IV
Case IX: Same as Case V

(d) Stability. - The crane shall have a factor of safety against overturning of at least 2 under any condition of loading. To meet this condition for diversion gate operation a temporary counter weight shall be provided, if necessary, at the lower sill on the downstream side and the structural members shall be designed to support the counterweight. If necessary for permanent operation a permanent counterweight shall be provided.

(e) Unbalanced tractive Effort. - The horizontal structural frame at the upper sills shall be adequate to prevent skewing under the actual unbalanced tractive effort caused by the two motors on one side driving the crane, loaded with a spillway gate, against a wind pressure of 10 pounds per square foot.

3-06. UNIT STRESSES.

(a) For Case I, the unit stresses in structural parts shall not exceed those specified by the American Institute of Steel Construction's "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings", as revised in 1936, except as otherwise modified herein, and except that all stresses shall be proportionately reduced to conform to a basic stress of 16,000 instead of 20,000 pounds per square inch for tension in net section.

(b) For Cases II & III, the resulting unit stresses shall not exceed 125% of those allowed for Case I.

(c) For Cases IV and VIII, the resulting unit stresses shall not exceed 90% of the elastic limit of the materials involved.

(d) For Cases V and IX, the stability requirement of paragraph 3-05 (d) shall be met.

(e) For Case VI, the resulting unit stresses shall not exceed 125% of those allowed for Case I.

(f) For Case VII, the resulting unit stresses shall not exceed 125 % of those allowed for Case III.

SECTION IV - STRUCTURAL DETAILS

4-01. GENERAL. - The gantry structure and trolley frame shall be built of structural steel shapes and plates. Shop connections may be either riveted or welded. Field connections shall be riveted. Webs of beams and channels shall be not less than 1/4 inch thick. All other structural material except sheathing, hoods and other covers shall be not less than 3/8 inch thick.

4-02. WELDED CONNECTIONS. - In the design of welded connections the following unit stresses in the weld throat shall not be exceeded:

Shear	11,300 pounds per square inch
Tension	13,000 pounds per square inch
Compression (on butt-welds)	15,000 pounds per square inch

Allowance shall be made for eccentricity in the section of the base metal parts, except that for fillet welds no allowance need be made for any bending couple caused by resultant stresses in the two fused legs of the weld. Stresses in fillet welds shall be considered as shear for any direction of the applied stress. Connection parts welded to form joints between members shall be designed to transmit the calculated stresses without exceeding the working stresses in the members. Where continuous welds are not required the welds shall be spaced not more than 18 inches apart in any continuous line, and on compression members such spacing shall not exceed 16 times the thickness of the thinnest metal. No weld shall be less than 2 inches long exclusive of craters. Overhead welding shall be used only where unavoidable.

4-03. PLATE GIRDERS. - Plate girders shall be proportioned by the moment of inertia of the net section. Wheel loads applied to flanges through rails shall be considered as distributed over a distance along the flanges not exceeding 36 inches. The rails shall not be considered as taking any portion of the top flange stresses. Girders of box section shall be provided with internal diaphragms at points of concentrated loading and at intervals of not over five feet throughout the length of the girder. Full depth diaphragms shall be used at intervals of not over ten feet. Other diaphragms shall have a depth not less than their width. Diaphragms shall be faced to insure full bearing of top flange cover plates, and end diaphragms shall also be faced for full bearing at the bottom. Diaphragms shall be riveted to both webs with sufficient rivets to transmit concentrated loads and with a pitch not greater than 6 inches.

4-04. LADDERS, PLATFORMS, WALKWAYS AND HAND-RAILING. - Ladders, platforms and railings shall be provided at all locations shown on the drawings or required by the design. Ladders shall be not less than 14 inches wide, with 7/8" diameter rungs spaced 12 inches on centers between 2 inch by 1/4 inch side bars. Platforms and walkways shall be floored with non-slip steel plate and provided with toe plates at all open edges. Walkways shall have a minimum net clearance of 24 inches. Hand-railing shall be provided along the open sides of all platforms and walkways where practicable. Railings shall be 42 inches high with an intermediate rail between the floor and top rail. Rails and posts

shall be standard 1-1/4 inch pipe with standard malleable iron railing fittings.

4-05. TROLLEY RUNWAY HOUSING. - The trolley runway housing shall be of copper-bearing steel plates, 3/16 inch thick, thoroughly braced with steel framing to withstand all loads and provided with ample louvres for ventilation as shown on the drawings. Where necessary for the convenient removal of machinery units, removable sections shall be provided in the housing. In addition, an opening 30 inches square shall be located at a convenient plate in the top of the housing for access to the roof. This opening shall be provided with a watertight cover which shall be readily removable from the inside and with suitable means for reaching the opening from the trolley or walkway.

4-06. OPERATOR'S CAB. - The steel framing and supports for the operator's cab shall be of ample strength to support the weight of all equipment, and shall be braced to withstand wind loads as well as forces and vibration due to operation of the crane. The sheathing shall be 1/8" copper-bearing steel plates secured to the framework in a manner to make a weatherproof enclosure with a smooth exterior surface. Means shall be provided for installation or removal of equipment.

Sash shall be provided at locations shown on the drawings. The sash on the upstream side of the cab shall be fixed, that on the downstream side of the casement type, and the end sash shall be of the commercial projected type. Glazing for the upstream side and ends shall be clear, shatterproof, polished plate glass, 1/4 inch thick. Glazing for the downstream side and for the cab doors shall be clear, polished wire-glass, 1/4 inch thick. All glazing shall be done from the inside by means of weather-tight glazing strips. Putty shall not be used.

The cab floor shall be covered with approved cement-asbestos board not less than 3/4 inch thick. The roof, walls and floor of the cab shall be insulated with rock wool of 4" minimum thickness.

4-07. COLLECTOR ARM. - The collector arm shall be of structural steel and located at the north portal frame on the upstream side as shown on the drawings. The connections to the crane frame shall be bolted so that the arm may be readily removed. The arm and connections shall be sturdy in design to prevent excessive deflection or distortion due to drag of the collector shoes or motion of the crane. The detail at the lower end of the arm shall be such that the width of opening in the conductor slot covering may be as small as possible and the conductors may be above the opening.

SECTION V-FABRICATION OF STRUCTURAL STEEL

5-01. GENERAL.- Fabrication of structural steel shall be in accordance with Section 25 of the "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" as adopted by the American Institute of Steel Construction, and revised in 1936, except as noted in paragraphs 5-02 to 5-05 inclusive.

5-02. HOLES.- For minor parts, holes may be punched full-size in material 3/4 inch or less in thickness, but shall be drilled full size in material more than 3/4 inch in thickness. For all other parts, holes shall be sub-punched and reamed after assembly in material 3/4 inch or less in thickness, but in material more than 3/4 inch in thickness shall be drilled full size after assembly, or drilled 1/8 inch less than the nominal rivet diameter before assembly and reamed full-size after assembly. Holes for turned bolts shall have a Class 4 fit with the finished shanks of the bolts as defined by Bulletin B4a-1925 of the American Standards Association.

5-03. PUNCHING, DRILLING AND REAMING.- For sub-punching, the diameter of the punch shall be 3/16 inch smaller than the nominal diameter of the rivet. For punching full-size, the diameter of the punch shall be 1/16 inch larger than the diameter of the rivet. In each case, the diameter of the die shall be not more than 3/32 inch larger than the diameter of the punch.

5-04. FIELD RIVETS AND ERECTION BOLTS.- Field rivets shall be furnished in the amount of 15% plus 10 rivets in excess of the nominal number of each size and length required. The contractor shall also furnish all necessary temporary erection and fitting-up bolts required for field erection.

5-05. WELDING

(a) Preparation.- Pieces to be joined by fusion welding shall be accurately cut to size and formed prior to welding. All forming shall be done by pressure and not by blows. The preparation of the edges to be joined shall be such as to insure thorough and complete penetrating; if necessary the edges shall be planed. The relative positions of the pieces at the time of welding shall be such that cooling of the weld will not set up excessive strains in the weld or the parent metal. All pieces to be welded shall be free from rust, paint, or other foreign matter for a distance of not less than 1/2 inch back from the welding edge.

(b) Welding Procedure.- All welding shall be done by the electric arc method, using a process which will exclude the asmosphere from the molten metal. The welding shall be done in a manner that will produce complete fusion with the parent metal. The welded joints shall be reasonably smooth and free from grooves, depressions, and other irregularities. All welding unless otherwise specified shall be in accordance with the applicable current codes, specifications. and recommended practices of the American Welding Society.

The contractor shall assign to each welder an identifying number, letter, or symbol which shall be stamped on the pieces adjacent to and at intervals of not more than 3 feet along the welds which he makes either by hand or by machine.

(c) Stress Relieving.- Welded parts shall be stress-relieved by

heating uniformly in an annealing furnace to temperature between 1100° and 1200° F. Each piece shall be brought slowly up to the specified temperature, held at that temperature for a period of time proportioned on the basis of at least one (1) hour per inch of maximum thickness, and then allowed to cool slowly in a still atmosphere. At no time during the stress relieving period shall there be a temperature differential greater than 200° F. in the piece being treated. Each piece shall be properly supported in the furnace to prevent distortion. Heating of any part of the structure after stress relieving will not be permitted. Stress relieving of welds in minor parts may be omitted upon specific approval by the contracting officer.

(d) Qualification of Welders.- The contractor shall furnish to the contracting officer satisfactory evidence that each welder to be employed on the work has within one year of the date of this contract satisfactorily performed the qualification tests prescribed by the American Welding Society in its latest "Code for Fusion Welding and Gas Cutting in Building Construction," using the detailed procedure to be followed in actual production under this contract. The contractor shall require any welder to repeat these tests when in the opinion of the contracting officer the work indicates a reasonable doubt of the welder's officiency.

SECTION VI - MECHANICAL EQUIPMENT

6-01. GENERAL. - All mechanical equipment shall be substantial in design, easily erected, inspected, adjusted, painted and taken apart. All mechanical parts shall be designed to withstand all dead and live loads with a factor of safety of not less than 5, without allowances for impact acceleration, or retardation, and also shall be proportioned to withstand additional loads produced by the rated breakdown torque of the motors without the resulting stresses exceeding 90% of the elastic limit of the material involved.

Castings shall be cleaned and all fins and other irregularities removed. Castings to be attached to structural steelwork or to other castings shall have their contact surfaces finished. Unfinished edges of castings, ribs, and similar parts shall have rounded corners and all inside angles shall have proper fillets.

Bolt heads, nuts, and washers shall bear on finished seats perpendicular to the axis of the bolts.

Machinery shall be mounted on rigid self-contained cast steel or welded steel frames or bedplates or on structural steel supports. The fastenings shall be adequate to hold the parts in place and alignment under all conditions of service. Turned bolts, dowels, or equivalent, shall be used to secure equipment in place. The deflection of machinery supports under maximum load shall be so limited as to cause no injurious misalignment of the equipment.

6-02. TRUCKS AND WHEELS. - Each gantry truck shall have four wheels and shall be equalized so that each wheel will carry its proportion of the leg load. The trolley shall be mounted on 4 trucks with 2 wheels each. Provision shall be made so that in the event of damage to any wheel, axle, or journal, the drop of the truck will not exceed one inch, and it shall be possible to remove readily the damaged part. Each end of each gantry truck shall be provided with substantial track clearers which shall be effective in both directions of travel and shall extend below the top of the rail on each side. Trucks shall also be provided with safety lugs extending below the top of the rail on both sides to prevent the truck leaving the rail. Bolted connections of trucks shall have contacting surfaces machine finished.

A bracket to support the truck drive motor shall be provided at the inner end of each truck. Motor and machinery shall be concealed by copper-bearing sheet steel as shown on the drawings.

All truck wheels shall be double flanged, rolled steel. They shall be of sufficient size to withstand adequately the maximum standing and rolling loads and shall be machined to limit the side movement to 3/4 inch on the head of a 175 pound crane rail, section number 175-418. The trolley truck wheels shall be not less than 24 inches tread diameter, and the gantry truck wheels shall be not less than 27 inches tread diameter.

6-03. TRUCK AXLES. - Truck axles shall be steel forgings, accurately turned all over, and ground and polished at the journals. Journals shall be of sufficient size to withstand adequately the maximum standing and rolling loads. All axles shall be forced into the truck wheels with a pressure of not

less than 8 tons per inch of axles diameter. The driving wheels shall be keyed to the axles in addition to the forced fit.

6-04. TRUCK JOURNAL BOXES. - Truck journal boxes shall be gray iron castings machined to fit rectangular finished seats on the wheel trucks and bored and fitted with "sealed" type phosphor bronze bearing bushings. The bushings shall be provided with openings at the bottom fitted with "Stapax", or approved equal, lubricating pad. The outer ends of the bushings shall be closed by bronze covers cast integral and the inner ends shall be flanged, counter bored and fitted with standard approved seals closely fitted around the axles. Provision shall be made to prevent the bushing from turning in the box. The boxes shall be provided with oil cellars with covers to permit renewal of lubricant and lubricating pad. Suitable oil drain plugs shall be provided in the bottom of the oil cellars. All bearings shall be drip-proof, watertight, and interchangeable.

6-05. GANTRY DRIVE. - The gantry shall be driven by four identical gear motors mounted one on each truck at the inner end; and the driving mechanism shall be arranged to drive the pair of truck wheels nearest the motor. The driving mechanism shall be so designed and shall have such capacity that the movement of the crane will be steady and the crane structure free from vibration or racking while moving at full speed and with full load against a wind pressure of 10 pounds per square foot of exposed surface. The combined capacity of the motors shall be sufficient to accelerate the loaded crane from standing to full speed against a wind pressure 10 pounds per square foot of exposed area of crane and gate in not more than 20 seconds.

6-06. TROLLEY DRIVE. - The trolley shall be driven by means of a motor mounted on the trolley frame and connected to one pair of driving wheels on each end of the trolley through gearing and shafting, substantially as shown on the drawings. The trolley drive shall be so designed that the travel will be steady and free from vibration or racking in any part under all conditions.

6-07. RAIL CLAMPS. - A manually operated locking device shall be provided by means of which the gantry may be secured to the runway rails at any point on the runway, to hold the unloaded crane against a wind pressure of 40 pounds per square foot.

6-08. GATE RETAINING LATCHES. - Gate latching devices shall be furnished to lock the gate securely against sidewise and endwise motion while it is being carried along the deck. The latches shall hold the gate in such a manner that the horizontal loads acting on the gate will be transmitted to the gantry structure.

6-09. LIFTING BEAM CENTERING PINS. - A pair of centering pins shall be mounted on structural steel frames on the underside of the trolley for the purpose of engaging the guide sockets in the top of the lifting beam. The pins shall be tapered to suit the guide sockets in the beam and shall have sufficiently close clearance in the sockets when the beam is at its highest position to hold it in place without excessive lateral movement. The pins

and frames shall be designed to transmit to the trolley its proportion of the maximum assumed wind load on a full depth gate section when the gate is secured to the latching devices on the lower sills.

6-10. MAIN HOIST. - The main hoist shall be of the single motor, double drum type mounted on the trolley framework.

Speed reducers shall conform to the specifications for Heavy Duty Speed Reducers adopted by the American Gear Manufacturers Association and shall be rated in accordance with the formulas recommended by that association. Flexible couplings shall be of standard or disengaging type, and of ample size and capacity for the service and loads.

6-11. AUXILIARY HOIST. - The auxiliary hoist shall be of the single motor, single drum type mounted on the trolley framework.

Speed reducer and flexible couplings shall be as specified in 6-10.

6-12. GEARING. - Gears may be of the herringbone, spur or worm type. Herringbone gears shall be of standard involute form, with 20-degree pressure angle. Spur gears shall be of the involute stub form with 20-degree pressure angle. Proportions of involute gears shall be according to the current recommendations of the American Standards Association. Work gears shall be of involute type. No spur gear pinions shall have less than 15 teeth. No motor pinions shall have less than 17 teeth.

Stresses in gears shall be computed by the Lewis formula, using the Barth formula for correction for speed. All gears shall be designed to take the entire pitch line load on one tooth. All pinions shall be annealed carbon-steel forgings, and all gears shall be carbon-steel castings, except the ring gears on main hoisting drums which shall be carbon steel forgings. In worm gearing the gear shall be of phosphor gear bronze, and the worm a steel forging. Gears shall out-mesh on top, where practicable. All gear teeth shall be cut from the solid.

6-13. BEARINGS. - Bearings shall be of the roller or ball type or shall have removable bronze linings. Shaft bearings shall be placed as close as possible to the points of shaft loading and shall be so designed that the bearing element may be easily replaced and that the shaft may be removed from the crane with its pinions and gears in position. Where divided bronze bearings are used the bearing caps shall be doweled and provision shall be made to hold linings effectively against the rotation or changing position under load. The top half of grease lubricated split bearings shall be drilled and tapped for lubrication fittings. All linings, thrust washers, and other surfaces requiring lubrication shall be grooved and open ends shall be sealed with approved grease retainers. All bearings shall be drip-proof and water-tight.

Where bronze linings are used, the bearing area shall be such that the product of the load, in pounds per square inch, and the square root of the rubbing velocity, in feet per second, will not exceed 900, but in no case shall the bearing pressure exceed 1300 pounds per square inch.

The minimum thickness of linings shall be as follows:

Shaft Diameter	Lining Thickness
Less than 2½ inches	1/4 inch
2½ inches to 4 inches	3/8 inch
4 inches to 5½ inches	½ inch

Ball or roller bearings shall be of standard type and of the highest grade of manufacture. Sizes shall be in accordance with the manufacturer's tables for the loads and speeds involved with not less than 100 percent added to the calculated loads to determine the required capacity to provide for shock loads.

Ball or roller bearings shall be mounted in accordance with the best engineering practice for the application under consideration and shall be inclosed in oil-tight inclosures with means for excluding dirt and retaining lubricant.

6-14. DRUMS. - The hoist drums shall be of close-grained cast iron or of welded structural carbon steel. They shall be of heavy section and ribbed to sustain the concentrated loads due to rope tension. The thickness of the drum under the ropes shall be not less than 1½ inches if of cast iron or 1-1/4 inches, if of welded steel for ropes over 1 inch of diameter and not less than 1 inch if of cast iron or 3/4 inch if of welded steel for ropes 1 inch or less in diameter. Each drum shall have right and left hand grooves, turned from the solid, to receive the hoisting rope. The grooved length of the drums shall be suffcient to take the full run of rope for the maximum lift plus two turns at each end. The rope attachement to the drum shall be simple and secure so that replacement of the rope may be made without dismantling the parts. Drums shall be pressed and keyed to the drum shaft; and shaft, gear, and drum shall be in proper running balance. The drum gears shall be pressed and keyed to the drum body. The pitch diameter for the drums shall be not less than 30 times the outside diameter of the rope. The various parts of welded drums shall be fitted together by machine grooving, turning or boring before welding as may be necessary to secure accurate assembly.

6-15. MECHANICAL AND HYDRAULIC BRAKES .-

(a) Main Hoist. - The drive of each hoist drum shall be equipped with a mechanical load brake which shall have capacity to hold 100% of the rated torque of the hoist motor, and which shall be designed to prevent the load from lowering unless the hoist motor is revolving under power in the lowering direction. Brakes shall preferably be of the type which utilizes the thrust of the worm gear in the speed reducer to produce pressure on friction disks, and which operate in conjunction with thrustor brakes on motor shaft and driven disk. Brakes shall run in a bath of oil and shall be so arranged that all strain due to loads is taken from the motors when the brakes are applied. At the full speed lowering position of the controller the regenerative action of the hoist motor shall provide the braking effect.

(b) Gantry Travel.- A hydraulically operated brake shall be provided to control the gantry travel in both directions. This brake shall be actuated by a foot pedal in the operator's cab and shall develop a retarding torque at the revolving motor shaft equal to the motor's full load torque when the pedal is under a pressure of not more than 50 pounds. The operating conditions for the crane require that it be accurately and quickly spotted over the gate openings, and the brakes shall be adequate for this purpose.

6-16. ROPE SHEAVES. - Rope sheaves shall be solid rolled steel. The rope grooves shall be turned. Pitch diameter or rope grooves for all moving

sheaves shall be not less than 27 times the diameter of the rope and for equalizing sheaves not less than 20 times the diameter of the rope. All sheaves shall be provided with anti-friction bearings or with phosphor bronze bushings forced into the hubs and dowelled. The design of the lower sheave blocks shall suit the design of the lifting beams to be used with the crane. Adequate provision shall be made for lubrication of all sheaves.

6-17. WIRE ROPE. - All hoisitng rope shall conform to Federal Specification RR-R-571, Type XXXIII, uncoated. No rope larger than 1-3/8 inches in diameter shall be used and if practicable, none over 1-1/4 inches. The ropes shall be of sufficient length to provide two extra turns on each drum plus adequate allowance for attaching to the drum.

6-18. SPRING BUMPERS. - The four corners of the crane shall be provided with spring bumpers to prevent injury to the crane, or to the loads being carried, by collision with the track stops or with another crane. The two bumpers at each end of the crane shall be capable of bringing the crane to a safe stop when traveling in either direction at rated speed with a load of 130 tons and the power cut off, without excessive stresses in the structure or equipment and with a minimum plunger travel of 5 inches. The bumpers shall consist of suitable springs, steel cylinders, and rams and shall be fastened securely to the trucks.

Spring bumpers shall be provided on the trolley runway to limit the travel of the trolley in each direction as shown on the drawings. They shall be attached to the trolley girders and shall contact lugs on the trolley frames. The two bumpers at each end of the trolley runway shall have sufficient capacity to bring the trolley, traveling at rated speed with power off and with a load of 130 tons, to a safe stop in five inches.

6-19. COUPLING EQUIPMENT. - Adequate means shall be provided on both sides of the north end of the crane, as indicated on the drawings, so that the crane, loaded or unloaded, may be towed or pushed along the runway by Crane No. 2 which will be of like construction to Crane No. 1.

6-20. SHAFTING AND COUPLINGS. - Shafting shall be amply proportioned and supported and provided with adequate means to prevent longitudinal movement. All shafting 3 inches in diameter and larger shall be made from hot-rolled steel bars, turned and ground, with fillets of not less than 1/4 inch radius where changes of section occur, and shall be polished at the bearings. Shafting smaller than 3 inches may be made of cold-finished steel, if of uniform diameter, otherwise of hot-rolled steel bars. Flanged couplings of the rigid type shall be carbon-steel forgings with safety type flanges, finished all over and fitted with turned bolts. Couplings shall be strong enough to develop the full strength of the shafting which they connect, and shall be pressed and keyed to the shafting.

6-21. BOLTS AND NUTS. - All bolts, nuts, and studs, except fitting-up bolts, shall conform to the American Standards Association's requirements for semi-finished, washer-faced hexagon heads and nuts with cut threads, coarse thread series, Class 2 fit. Heads shall be of "American Standard, regular" and nuts shall be of "American Standard, heavy" proportions.

Turned bolts shall meet all the requirements of bolt and nut specifications, and, in addition, the diameter of the shank shall be 1/16 inch larger than the

nominal diameter of the thread and shall be turned truly cylindrical within the limits and tolerances of a Class 4 fit of the American Standards Association. Holes in the parts shall be correspondingly reamed. The unthreated portion of the shank shall be 1/16 to 1/8 inch longer than the thickness of the connected members. Each bolt shall be provided with a washer 1/4 inch thick.

6-22. KEYS AND KEYWAYS. - Keys shall, in general, conform to the American Standards Association Specifications B17-1-1934, for Shafting and Stock Keys. If two or three keys are used, they shall be placed 120° apart.

6-23. GEAR CASES, GUARDS, AND COVERS. - All gears excepting the drum gears and pinions, shall be inclosed in oil tight cases provided with felt seals, oil level gauges or plugs, and drain plugs, and so arranged that one-half of the case may be easily removed for complete inspection of the gears. Access hand holes with tight cover plates shall be provided. Gear cases may be made of cast iron, steel castings, or 3/16 inch minimum thickness steel plate, riveted or welded.

Wheel guards for the gantry trucks shall be steel castings or steel plate not less than 3/8 inch thick. Guards for drum gears and pinions shall be not less than 1/4 inch thick.

Suitable drip pans made of steel plate not less than 3/16 inch thick shall be provided to collect oil and grease which may drop from operating parts. All gear cases and drip pans shall be provided with means for cleaning and draining without dismantling any of the equipment.

6-24. LUBRICATION. - The lubrication of the mechanical parts of the crane shall be by means of high pressure grease, except that lubrication of the motors and speed reducers shall be as provided by the manufacturer of these units, and that packed type journal boxes for the gantry and trolley trucks shall be provided with Stapax journal lubrication or equivalent. All high-pressure grease-lubricated points shall be provided with industrial type button-head fittings which shall be located in readily accessible positions. If necessary, the fittings shall be connected with the points of lubrication by tubing which shall be of copper or brass, of ample size and strength to withstand the cold lubricant working pressure, and securely fastened.

6-25. TOOLS AND INSTRUCTIONS. - A complete set of high grade wrenches and other necessary tools shall be provided in sufficient variety to turn every size bolt, nut, and screw on the crane and including any special tools necessary to reach difficult positions. Each tool shall be stamped or provided with a metal tag so that it may be easily identified as to its use and size. Suitable metal racks shall be provided in the operator's cab with a designated place for each tool and with space for grease gun and oil can. A metal rack for a complete set of spare fuses and light bulbs shall also be installed in the cab. The tool rack and the fuse rack shall each be mounted in a substantial metal case with hinged door and catch. One grease gun, one oil-can and one set of spare fuses shall be furnished.

A complete set of instructions covering the care and operation of the crane shall be provided for reference. In addition, a printed copy or black line print of general operating instructions, mounted in a metal frame fitted with a glass cover, shall be installed in the operator's cab.

6-26. NAME PLATES. - The contractor may furnish and attach to the crane structure one name plate measuring not more than 12 inches by 18 inches stating the rated capacity of the main hoist and the auxiliary hoist and the contractor's name.

SECTION VII - ELECTRICAL EQUIPMENT

7-01. GENERAL. - All electrical equipment and wiring on the cranes shall conform to the requirements of the National Electrical Code, the National Electric Safety Code, and the Standards of the National Electric Manufacturers Association, except as otherwise specified herein. All safety devices such as mats, railings, screens, guards, or equipment required to meet these codes and standards shall be furnished by the contractor. All equipment and devices necessary for proper operation of the crane in the manner specified, whether or not particularly called for, shall be furnished by the contractor.

The power supply will be at 440 volts, 3 phase, 60 cycles, and will be taken to the crane collectors through main copper conductors furnished by the Government and located in a recess in the upstream side of the dam below the level of the deck.

All safety switches, drum switches, magnetic switches, main line contactors, and main wiring shall be furnished with sufficient mechanical thermal, and short-time current capacity to be fully protected by the main fuses under short circuits of any value up to 10,000 RMS amperes.

7-02. MAIN CONDUCTORS ON DAM. - The main conductors in the slot on the upstream side of the spillway bridge and north bulkhead, together with steel supports, connection and covers, will be furnished by the Government.

7-03. COLLECTORS AND CONDUCTORS ON CRANE. - The contractor shall furnish, for the main power take-off, bronze shoe collectors installed on the steel collector arm (paragraph 4-07) and designed to operate on the curved main conductors. The shoe collectors shall be Electric Service Supplies Company, Type LM, or equivalent, with porcelain or composition insulators rated not less than 1000 volts.

The contractor shall provide approved insulated flexible power and control cables looped from a terminal box, attached to the roof structure of the trolley housing, to a terminal box on the crane trolley. For temporary service during diversion gate operation, the total trolley travel will be approximately 34 feet, but for permanent operation it will be approximately 21 feet. The cables shall be of sufficient length to permit operation of the trolley for temporary service, but provision shall be made for conveniently shortening the cables for permanent service. The cable installation shall provide secure anchorage and support, as well as maximum protection against abrasion and other mechanical injury. The cables shall be made of extra flexible individual conductors insulated as specified in paragraph 7-13, and in addition each cable assembly shall have a 60 percent tough rubber jacket.

7-04. MAIN SUPPLY SWITCH. - A three-pole, single-throw, bottom-fused, 400 ampere, 575-volt, inclosed safety switch with 400 ampere non-renewable fuses shall be provided in the supply circuit. The switch shall be conveniently located near the cab entrance. A 25 watt pilot lamp and resistor connected to the supply side of the main switch shall be provided and installed on the switch inclosure.

7-05. MAIN SUPPLY CONTACTOR. - A 300 ampere, 575-volt, inclosed type, 3-pole main contacter shall be provided and connected so that it will be tripped instantaneously by overload on any main motor circuit and by all em-

ergency circuits and protective devices. The circuit also shall be connected so that all drum controllers must be in the "off" position before the main contactor can be reclosed. The contactor shall operate within the voltage and temperature limits specified in paragraph 7-07.

A heavy duty "Start-Stop" push button station shall be located conveniently near the operator's stand to provide for emergency trip.

A weatherproof, heavy duty, maintaining contact push button station shall also be provided, within reach from the deck, near each end of the crane, on the downstream bottom sill. The push button switch shall interrupt the control circuit of the main supply contactor to provide emergency shut-down of the entire crane.

7-06. CONTROLS. - The master switches and control panels shall be located in the operator's cab and arranged so that one operator may control all functions of the crane with maximum convenience and visability. Interlocks shall be provided to limit operation to only one motion at a time.

The controls for the main hoist, auxiliary hoist, and gantry drive motors shall be of the full magnetic, reversing, time-limiting acceleration type, operated by master switches with vertical handles. The gantry travel motors control shall be so connected that all four motors must operate together and shall have a drift point for both directions of travel for operating a thruster motor brake circuit magnetic contactor. The control for the trolley travel motor shall be of the semi-magnetic, reversing type operated by a drum switch with a vertical handle. The reversing may be done by means of contactors in the controller itself.

Each drum and master switch shall be provided with a vertical handle and deadman pilot contact control or spring return. All motor controls shall have not less than five accelerating points and shall limit the operation of the motor to that accelerating point corresponding to the position of the master switch. Each drum and master switch shall be inclosed in dust-tight cases and shall be provided with conduit entrance boxes. The bearings shall be of the removable bushing or ball-bearing type. The drum contact fingers shall be self-aligning and adjustable to compensate for wear and shall be easily renewable. Terminals for clamp-type solderless connections shall be provided for all leads and shall have identifying markers.

The magnetic contactors for each motor shall be mounted on a moulded ebony asbestos panel not less than 1½ inches thick and each panel shall be mounted in a totally inclosed ventilated steel cabinet provided with removable panels in the rear and hinged doors with three point vault type latches and handles in the front.

A two-element instantaneous overload relay shall be provided for each motor. Each relay shall be adjustable over a range of 150 to 300 percent of the normal full load rating of the connected motor. Operation of the motor relays shall trip the main line contactor.

Secondary controls shall be rated at least equal to the highest voltage obtained at the slip-rings of the motors under plugging conditions specified in paragraph 7-09.

A three-pole, single-throw, 200 ampere, 575-volt, unfused knife switch shall be provided for each hoist and gantry travel motor branch circuit, ahead of the overload relays and primary contactors. A three-pole, single-throw, 100 ampere, 575-volt, bottom fused knife switch shall be provided in the trolley travel motor circuit ahead of the overload relays and primary contactors.

A two-pole, 60 ampere, 575-volt knife switch with 30 ampere fuse clip and non-renewable fuses shall be provided for each motor control cir-

cuit and shall be connected on the supply side of the three-pole motor knife switch in such a manner that all motor control contactors can be operated from the drum controllers without supplying power to the motors.

7-07. MAGNETIC SWITCHES. - Each magnetic switch shall have an inclosed capacity not less than 100 percent of the full rating of its connected motor or load, but in no case less than 75 amperes, with temperature rise of contacts not to exceed 65 degrees centigrade above 40 degrees centigrade ambient air outside the inclosing case. Each switch shall be designed for full voltage line start motor control and shall be provided with arc suppressors. All operating coils shall operate successfully on any voltage from 85 to 110 percent of normal, and the maximum temperature rise shall not exceed 65 degrees centigrade measured by thermometer above an ambient temperature of 40 degrees centigrade outside the inclosing case. Each switch shall be inclosed in a safety type steel inclosure or mounted on a control panel which shall be inclosed as specified in paragraph 7-06.

7-08. LIMIT SWITCHES. - Limit switches shall be provided to control the upper limits of travel of the main hoist and of the auxiliary hoist. The trolley travel and the gantry travel shall be controlled in both directions by limit switches. For temporary operation of the trolley on the cantilever arm, provision shall be made so that the crane operator may manually by-pass the switch limiting the trolley movement in the upstream direction. Trippers for operating the gantry travel limit switch shall be furnished by the contractor for installation by the Government near each end of the runway. One tripper will be installed temporarily to limit the gantry travel to a point south of the center line of Pier No. 14; and the design shall permit its removal and reinstallation, near the north end of the crane runway after the dam is completed.

Limit switches shall be connected in pilot circuits only. The making and breaking of the contactor operating oil currents shall be done by suitable relays of ample capacity. They shall be of the outdoor, weatherproof type and shall be provided with conduit connections. All limit switches shall reset automatically.

7-09. MOTORS. - All motors shall be rated 440 volt, 3-phase, 60 cycles, with torque and capacity as required for the duty specified and with frame type, time and temperature ratings, and speeds as follows:

Motor	Frame Type	Time & Temp. Rating	Synchronous Speed Not to exceed
Main Hoist	Open	60 Minute	
	Wound Rotor	50° C.	600
Auxiliary Hoist	Open	60 Minute	
	Wound Rotor	50° C.	900
Trolley Drive	Open	30 Minute	
	Wound Rotor	50° C.	900
Gantry Travel	Open	60 Minute	
	Wound Rotor	50° C.	1800
	Gearmotors		

Commercial tests shall be made on all motors in accordance with NEMA Code MG9-541. Four copies of each test shall be submitted to the contracting officer for approval.. Each motor shall have ball or roller bearings in dust-proof housings having adequate means of retaining the

correct amount of lubricant without dripping. Windings shall be insulated with AIEE Class "A" insulation, especially impregnated to withstand moisture and braced to withstand starting, running, and plugging stresses. All motors shall withstand 50 percent overspeed and plug ging at 100 percent speed without mechanical injury and without the secondary voltage exceeding the rated voltage of the secondary controls. The starting torque of all motors shall be not less than 200 percent of full load torque at rated voltage with the rotor in the angular position for minimum torque and with secondary resistance of value for maximum torque. Each slip ring shall have at least two brushes with flexible copper shunts.

7-10. - POWER FACTOR CORRECTION. - Static capacitors shall be provided for power factor correction of the main hoist motor and the gantry travel motors. The capacitors shall be connected directly to the motors so that no additonal control or protective equipment will be required. Capacities shall be rated in Kva at not less than fifty percent (50%) of the horse power rating of the motors to which they are connected. Capacitors shall be similar and equal to Type FP, manufactured by the Westinghouse Electric and Manufacturing Company.

7-11. ELECTRIC BRAKES. - All motors shall be provided with shoe type brakes of rugged construction and positive action. They shall be so arranged that they may be released manually, but cannot be locked in the release position. The main hoist shall be equipped with thrustor brakes, floor mounted, with the rating at each drum 100% of the rated motor torque. The auxiliary hoist motor and each gantry travel motor shall have floor mounted thrustor brakes, each rated at150% of the rated motor torque. The trolley drive motor shall have a motor mounted thrustor or solenoid brake rated at 150%of the rated motor torque.

All brakes shall have non-corrodible operating mechanism wearing parts, shall be self-aligning, and shall have independent adjustment for lining wear and torque. Thrustor windings and solenoid coils shall have special moisture-resisting Class A insulation. The temperature rise of the brake solenoid coils shall not exceed 65 degrees C. by thermometer and the temperature rise of the thrustor motors shall not exceed 55 degrees C. above 40 degrees C. ambient air under continuous service. The brakes on the gantry travel motors shall be designed for quick release, and for gradual application which shall be adjustable over a period of one to twenty seconds inclusive. All other brakes shall be designed both for quick release and quick setting without undue shock or impact.

7-12. RESISTORS. - Resistors shall be of non-corrodible resistor metal strap having negligible temperature coefficient of expansion, edgewise wound about an insulating support. The resistor design for the various motors shall conform to suitable NEMA classifications for continuous duty, and shall be of sections suitable for five accel rating points. Barriers of compressed asbestos fibre composition shall be provided between motor starter resistor assemblies. All resistor assemblies shall be mounted in a suitable, inclosed, weatherproof,ventilated space, preferably above the operator's cab.

7-13. INSULATED CONDUCTORS, WIRING AND CONDUIT. - All wiring shall be furnished, and installed as far as practicable, by the contractor. All wiring except flexible cables shall be installed in rigid, threaded, galvanized

steel conduit with watertight junction and pull boxes at intervals close enough to allow the cables or wires to be pulled without abrasion or injury. Conduit shall conform to Federal Specifications WW-C-581-A with both inside and outside surfaces and all threads zinc-coated. The conduit shall form a continuous watertight system, rigidly supported. Where conductors connect to the current collectors or trolley conductors, conduit fittings with gaskets shall be installed with necessary drip loops. The entire conduit system shall be grounded and drained. No conduit shall be smaller than 3/4 inch size.

The wire for the service between the main collectors and the main switch shall be stranded copper and not less than 4/0 AWG. All wiring except that adjacent to resistors and except control panel wiring shall be of stranded copper, insulated in accordance with Federal Specification JC-106a. All panel wiring shall be minimum No. 12 AWG, tinned, solid, and equal to Rockbestos Products Corporation 600 volt Rockbestos switchboard wire. All wire adjacent to resistors shall be stranded, equal to Rockbestos 600 volt rheostat wire.

7-14. SANDERS. - One electormagnetic sander shall be provided for each gantry truck. The sander hoppers shall have approximately two-cubic foot capacity. Each shall be equipped with a solenoid-operated brass sand valve and a totally inclosed watertight heating element suitable for continous service. The sanding pipes shall be arranged to deliver sand as near as possible to the contact point between the crane rail and truck wheels for both directions of travel.

A 60 - ampere, 575 volt, 2-pole, fused, safety switch shall be mounted in the operator's cab and connected to the 440 volt main bus to supply service to the sander heating elements. The solenoid valves shall be controlled by a 600 volt foot switch on the cab floor. Sanders as manufactured by the Nichols-Lintern Company, or equal, will be acceptable.

7-15. LIGHTING. - A weatherproof lighting installation shall be provided to illuminate the area in front of the operator's cab, gate slot, and a portion of the runway at each end of the gantry crane as indicated on the drawings. The lighting units shall be of the types shown on the drawing and in addition thereto, an adequate number of suitable lighting units shall be provided in the operator's cab and in the trolley housing, 110-volt plug receptacles shall be provided as indicated on the drawings. The lights and plug receptacles shall be energized by a 440-220/110 volt, dry-type, two-winding transformers of adequate capacity mounted on the crane and fed from the 3-phase power supply. The 440-volt branch circuit for the lighting system shall be protected by a suitable circuit breaker. A 115/230 volt panel board shall be provided in the operator's cab and shall contain at least 2 spare single-pole circuit breakers in addition to those required for protecting and controlling the branch circuits to lights and plug receptacles.

7-16. WARNING SIGNAL. - The crane shall be provided with one double-headed, motor driven, vibratory type, 110-volt, single-phase, weatherproof heavy-duty siren, as manufactured by the Electric Service Supplies Company, or equal, so mounted as to signal in both directions of travel. A foot-operated switch shall be provided in the operator's cab for operating the siren.

7-17. NAME PLATES AND MARKERS. - Each push button, control switch, circuit breaker, magnetic switch, drum controller, knife switch, and motor pro-

tective relay shall be provided with an approved name plate, containing an inscription which shall give the circuit and the function of the device. Suitable markers shall be provided for all resistors, conduits and wiring. These markers may be suitable tags or name plates securely fastened to the device.

7-18. GASOLINE-ELECTRIC GENERATING UNIT.

(a) General. - The gasoline-electric generating unit shall consist of a gasoline engine of not less than 6 cylinders direct connected through a flexible coupling to a 156 Kva 80% power factor, alternating current generator, mounted on a cork insulated common base. The contractor shall furnish the accessories listed in paragraph 7-18 (b)(15), and all other parts, fittings or accessories necessary for the complete installation, including switchboard and electric wiring from the generator.

(b) Gasoline Engine.

(1) The engine shall be of the 4-cycle internal combustion type, and shall be capable of developing not less than 200 brake HP for continuous operation at 1200 R.P.M., operating on gasoline conforming with Federal Specification VV-G-101a, "Gasoline, Motor, U.S. Government".

(2) Governor. - The engine shall be equipped with a suitable governor. The normal full load speed of the engine shall be 1800 R.P.M. and the normal no load speed shall not exceed 1890 R.P.M. The speed of the engine may vary between 1800 R.P.M. and 1890 R.P.M., in proportion to the percentage of loading, but for any constant loading between no load and full load, the speed shall not fluctuate more than 1½%, from the normal speed for such percentage of loading. When the engine is running with no load and full load is suddenly applied, the speed shall not fall more than 6% below full load speed and shall return to normal full load speed within 6 seconds. When the engine is running under full load and the load is suddenly thrown off the speed shall not increase more than 6% above the normal no load speed and shall return to the normal no load speed within 6 seconds.

(3) Cylinders. - The cylinders shall be cast from hard close grained gray iron or of nickel alloy iron. The cylinders may be cast enblock or in pairs, but shall not be cast integral with the crank case. If cast in pairs they shall be provided with removable wet sleeve liners. They shall have water jackets of ample size to insure thorough circulation and uniform cooling.

(4) Cylinder Heads. - Cylinder heads shall be removable, completely water jacketed and preferably of the same material from which the cylinders are made. They shall be secured to the cylinders with a sufficient number and size of studs to insure freedom from gasket leakage.

(5) Piston and Pins. - The pistons shall be a suitable lightweight alloy. The piston pins shall be provided with liberally proportioned bearings.

(6) Connecting Rods. - The connecting rods shall be forged from high-grade material, heat treated. The crank pin end of the rods shall be machined and fitted with renewable, bronze or steel backed, babbit-lined bearings.

(7) Crankshaft. - The crankshaft shall be drop forged from a suitable high-grade steel and heat treated. The crankshaft and reciprocating parts shall be dynamically balanced for the normal speed range of 1800 to 1890 R.P.M. and there shall be no injurious vibrations at any operating speed up to 40% above normal no load speed.

(8) Camshaft. - The camshaft shall be drop forged with cams forged integral and all cams and bearings ground to size. The camshaft may be driven by an arrangement of gears or may be chain driven. The proportions of parts

and materials used in the camshaft drive system shall be such as to insure long life and quiet trouble-free operation. Adequate provisions shall be made for lubrication of all parts.

(9) Main Bearings. - The number of main bearings shall not be less than four. The bearings shall be so designed and placed that they may be replaced without difficulty. The main bearings shall be fitted with renewable bronze or steel backed, babbit-lined bearings or other equally suitable metal.

(10) Crank Case. - The crank case shall be made of suitable material and of sufficiently rigid construction to hold all cylinders, bearings, and other working parts in proper alignment. They shall be provided with inspection plates so arranged as to give easy access to the interior of the crank case for inspection and the adjustment of connecting rods and other parts. The crank case shall be so arranged as to present a neat appearance and shall be mounted upon a suitable sub-base or bed-plate common to both engine and generator.

(11) Valves. - The valves shall be of a material that will withstand high temperatures without warping or pitting. They shall be so proportioned for area and lift as to insure low velocities for entry and exit of gas and quiteness in operation.

(12) Lubrication. - The engine shall be provided with a suitable arranged oil pump which shall deliver lubricating oil under pressure to the main bearings, crank pin bearings and camshaft bearing and if the engine is of overhead valve type, to the valve rocker arms. Pressure lubrication of piston pins, timing gears, cams and valve tappets will not be required if other means which will insure ample lubrication are provided.

(13) Cooling System. - The engine shall be provided with a radiator of high-grade construction and material, and of sufficient cooling capacity to keep the cooling water below the boiling temperature under continuous full load operating conditions, when the ambient temperature is 100 degrees F. A suitable fan, driven by the engine, shall be provided for circulation of air through the radiator. The radiator shall be provided with a suitable sheet metal hood to exhaust the air.

(14) Ignition System. - The engine shall be provided with dual ignition. One system shall operate from the storage battery and shall consist of breaker, distributor, coil and high-tension wiring to a spark plug in each cylinder; the other system shall consist of a suitable magneto with impulse starter couplings, breaker points and distributor and shall have high tension wiring and spark plugs entirely independent of the battery ignition system. The magneto shall be driven through an impulse coupling and the engine provided with suitable means for hand starting or magneto ignition in case of the failure of batteries.

(15) Engine Accessories. - The following accessories shall be furnished by the manufacturer of the engine.

a. Electric Starter
b. Electric generator for starter equipment
c. 12-volt heavy duty type battery, in black steel japanned or enameled case, lead lined on the inside and mounted in or attached to the base
d. Oil cooler and filter
e. Air cleaner and fire screen
f. Water circulating pump
g. Engine driven fuel pump
h. All special tools and wrenches

i. Instrument board, mounted on the engine and containing an oil pressure gauge, ammeter, selector ignition switch, start switch and tachometer

j. Flexible coupling similar or equal to the "Fast" type, with suitable guard, for connecting engine to the generator

k. Overspeed ignition cut-out switch

l. Water temperature thermometer

(16) Miscellaneous Parts. - The contractor shall furnish the following items for the unit and such other parts necessary to complete the installations:

a. Hand operated gasoline pump to supply fuel tank

b. 60-gallon capacity fuel tank

c. Dry exhaust muffler, Maxim, Burgess or equal

d. Complete fuel and air vent system

e. Flexible metal exhaust hose fitted with brazed metal, connections and flanged to fit engine exhaust manifold.

(17) Spare Parts. - The contractor shall furnish the following spare parts:

1 only piston, complete with rings, connecting rod and wrist pin with shims and bolts
1 only cylinder head
2 only cylinder head gasket
1 only complete set of exhaust and intake valves, with springs and other pertinent parts
1 only complete engine water circulating pump
1 only complete set of spark plugs
1 only main bearing shell for each size and type used
1 pair crankpin bearing shells

The parts shall be suitably packed to prevent corrosion and the packages properly marked for identification.

(c) Generator, Exciter and Voltage Regulator.

(1) General. - The generator and exciter windings for each unit shall be insulated with class "A" insulation and thoroughly impregnated with "moisture and oil resistant" insulating compound and baked. Brushes shall be of ample size and brush holders sturdy in construction. Ferrous accessory parts of generator and exciter including bolts, screws, and brush holders shall be "Parkerized" or treated in a similar manner acceptable to the contracting officer. Details of construction shall be such as to provide satisfactory service under long periods of idleness in a damp atmosphere. Antifriction bearings of ample size enclosed in dust-proof housings shall be provided. The generator shall be connected to the engine by means of a flexible coupling. A suitable exciter field rheostat arranged for mounting off the rear of the switchboard and for operation by a hand-wheel from the front of the switchboard shall be provided. The overall diameter of the rheostats including the mounting holes shall not exceed 15 inches. The generator and exciter, unless otherwise required by these specifications, shall conform to the current rules, regulations and standards of the "National Electrical Manufacturers Association" and the "American Institute of Electrical Engineers". All parts of the generator and excitor shall be easily accessible for inspection, repair and replacement. Provision shall be made for feeding power from the generator, through the collector into the collector bus, for use

on the other crane or other equipment.

(2) Generator. - The generator shall be of the revolving field, synchronous type with direct-connected excitor and shall be of standard construction with drip-proof covers. The generator shall have a capacity of 156 Kva, with 80% lagging power factor, 50 degreesC. continuous duty, 1800 R.P.M., 3-phase, 60 cycle, 480 volts. The stator leads shall be of extra flexible stranded cable and provided with terminal lugs housed in a terminal box with a removable cover. Terminal lugs shall be provided at the rotor brush holders for making the necessary field connections, and a suitable terminal clamp or box shall be mounted for supporting the field leads. Frame and end brackets shall be of refined cast iron, the feet being cast integral with the frame or of equally sturdy construction. Amortisseur windings shall be provided and shall be of copper bars driven through slots in the pole faces and welded to common end rings. The end rings shall consist of sections corresponding to the pole pieces. The ring sections shall be securely bolted together where they adjoin. Collector rings shall be of bronze or brass securely mounted and adequately insulated from the shaft in accordance with approved construction methods. They shall be smooth and assembled concentric with the shaft on which they are mounted. The voltage regulation of the generator at 80% power factor lagging shall not exceed 30 percent. The full load efficiency of the generator, not including rheostat or exciter losses, shall not be less than 85% at 80% power factor lagging.

(3) Exciter. - The exciter characteristics shall be such as to provide good regulation of the generator up to 150% of rated load at 80% lagging power factor and shall be designed for operation with an automatic voltage regulator. The terminal voltage shall be 125 volts, D.C. It shall be supported on the generator end bracket, and the armature sleeved on the generator shaft. The frame shall be of drip proof construction. Satisfactory commutation shall be obtained throughout the load range required by the generator without adjustment of the brushes. The commutator shall be smooth, true and concentric about its shaft. Brushes shall not chatter or stick in holders. The loads from the excitor shall be inclosed in a terminal box mounted on the exciter frame with each lead properly identified.

(4) Automatic Voltage Regulator. - The contractor shall furnish an automatic voltage regulator to be used in connection with the operation of the unit. The voltage regulator shall be mounted on the switchboard. The automatic voltage regulator shall be similar and equal to General Electric Company type GDA or Westinghouse Electric and Manufacturing Co. "Silverstat" regulator and shall be of suitable design for satisfactory operation with the generator and its exciter. The sensitivity of the regulator shall be within plus or minus two percent at normal voltage and 80% power factor. The regulator shall include the furnishing of all necessary auxiliary equipment such as condensers, external resisters and potential transformer.

(5) TESTS. - The generator and excitor shall be assembled at the manufacturer's plant and the following tests made on the generator in the presence of a duly authorized representative of the contracting officer.

a. Resistance of stator and field windings
b. Polarity of all field poles
c. Efficiency at 1/2, 3/4 and full load; all at 80% power factor
d. Regulation at rated load
e. Heat run
f. Dielectric test

Three certified copies of the above test data shall be supplied to the

contracting officer. Three certified copies of tests on the exciter in accordance with paragraph MG9-55 of "N.E.M.A., Motor and Generator Standards" Publication No. 38-49, May 1938, shall be submitted to the contracting officer. Above tests shall be made in accordance with the latest standardization rules of the American Institute of Electrical Engineers.

(6) Spare Parts. - A spare set of generator and exciter brushes shall be furnished.

(d) Battery Charger. - A battery charger suitable for operation on a nominal 115 volt, 60-cycle, A.C. circuit and with a capacity of 6 amperes D. C. shall be provided. The D.C. voltage shall be adjustable from 6 volts to 45 volts. The battery charger shall be equipped with a D.C. output ammeter, a switch and a fuse to protect it against overloads and short circuits. The battery charger shall be designed so that the battery will not discharge in case of A.C. voltage failure and the charger will resume normal operations when line voltage is restored. It shall have a tapering charging rate and be inclosed in a wall mounted steel cabinet with hinged door. The finish shall be rust-resisting and durable. The polarity of the D.C. leads or terminals shall be plainly marked.

(e) Bed Plate. - The bed plate for the unit shall be designed by the contractor and shall be integral for engine and generator. The sub-base or bed plate shall be of rigid construction and may be either an iron or steel casting or it may be fabricated by welding of structural steel plates and shapes. It shall be the responsibility of the contractor to furnish a design which will not result in excessive vibration of the unit and the bed plate shall rest on "Vibracork", or equal, or on suitable springs. If cork is used the bed plate shall be provided with drip-proof edges and suitable arrangement for retaining the cork in proper position. A design of sub-base of unsightly appearance or which would be, in the opinion of the contracting officer, otherwise unsuitable will not be accepted. The cork furnished under this contract shall be 2" thick and shall be Armstrong Cork and Insulation Company's "Vibracork", light density, or approved equal. This reference given is for descriptive purposes only. Structural steel angles, suitable in size and form to fit around the bed plate and secure to the floor, shall be provided for retaining the cork insulation.

(f) Shop Inspection and Tests. - The unit shall be assembled in the contractor's shop for shop inspection and the following tests shall be made under the conditions specified in sub-paragraph 7-18(b)(2). The tests shall be made in the presence of a representative of the contracting officer. All tests shall be made at the expense of the contractor except the expenses of the Government Inspector.

a. The engine only shall be run for two (2) hours at full rated H.P. on dynamometer test

b. The combined unit shall be run continously for twenty-four (24) hours at full load or directed.

c. The carburetor butterfly valve setting and governor control shall be carefully checked with the entire unit operating under various load conditions ranging from no load to 115% of the generator rating. During these tests the following shall be recorded:

R.P.M. - load - exhaust temperature - circulating water temperature, lubricating oil temperature-fuel consumption, and such other data as may be required by the contracting officer or his representative.

Typewritten records of all the above tests, including all observations, calculations, results and graphs, all certified, shall be submitted in triplicate by the contractor to the contracting officer as soon as practicable after completion of the tests. Final test and trials will be made after installation and will be of sufficient duration to demonstrate to the satisfaction of the contracting officer that the units are in conformity with the specifications. The tests shall be run with gasoline conforming to Federal Specifications VV-G-101a for "Gasoline; Motor, U.S. Government".

(g) Tests After Alteration.- In the event that the unit does not meet all the requirements of these specifications, the contractor shall make such alterations and replacements as may be necessary to insure that the performance of the unit meets the requirements. The expense of additional tests, if required shall be borne by the contractor.

7-19. OPERATOR'S CAB HEATERS. - Built-in electric heaters shall be provided in the operator's cab. They shall have variable control for three-heat operation and shall be capable of maintaining a temperature differential of 100 degrees F. over the outside air when operating at full load with the cab insulated as required by paragraph 4-06.

SECTION VIII - MATERIALS

8-01. GENERAL

(a) Materials. - All materials shall be of new, unused stock and free from defects. Materials indicated on the drawings or required in the work and not covered elsewhere in these specifications by detailed requirements shall conform to the requirements of this section. Any material required which are not covered by detailed specifications herein or elsewhere in the specifications shall conform to the applicable Federal Specifications, grade and/or class as required or, in case there are no applicable Federal Specifications, to applicable specifications of the American Society for Testing Material (A.S.T.M.). In all other cases not specifically covered herein the contractor shall furnish the highest grade commercial material or product.

(b) Shop Inspection and Material Orders. - Material and equipment ordered by the contractor for this work shall not be shipped from its point of manufacture before it has been inspected, unless the contracting officer authorizes the inspection to be made elsewhere. The contractor shall furnish to the contracting officer a list of sub-contractors and vendors with whom orders are to be placed for materials or equipment which will enter directly into the work of this contract; and,also, triplicate copies of mill and shop orders as they are issued. Copies of orders shall be issued far enough in advance of the beginning of operations to permit the making of arrangements for inspection. Mill and shop orders shall bear notations showing that the material is subject to Government inspection, the specification designation under which the material ordered is to be furnished, and the drawing and part number, if any, pertinent thereto. The contracting officer may accept certified copies of test reports in lieu of inspection at the point of manufacture.

Except as otherwise provided, the inspection and testing of metals shall be carried out in accordance with the requirement of Federal Specification QQ-M-151a.

(c) Tests. - The contractor shall at his expense, in all cases except upon specific waiver by the contracting officer, prepare specimens and perform tests and analyses as required to demonstrate conformance of the various materials with the pertinent specifications, and shall furnish to the contracting officer certified test reports in triplicate. He shall also furnish to the contracting officer test pieces and samples for independent analysis and test if requested.

(d) Federal Specifications. - Copies of Federal Specifications referred to herein may be procured from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a price of five or ten cents each. When the term, "Federal Specifications" or "A.S.T.M. Specifications" is used, the reference shall be construed to mean the cited specification as modified by any amendments made before the date of opening bids for the contract.

8-02. STRUCTURAL CARBON STEEL. - Structural carbon steel shall conform to Federal Specification QQ-S-711a for "Steel, Structural; (for) Bridges", Class A. Surface imperfections shall be remedied by arc-welding and according to Government practice. The chemical properities of the steel shall be such as to permit it to be readily welded by this process.

8-03. COPPER-BEARING STEEL SHEETS AND PLATES. - Copper-bearing steel sheets and plates shall conform to Federal Specification QQ-S-711 a for "Steel, Structural; (for) Bridges" Class B.

8-04. RIVET STEEL. - Rivet steel shall conform to Federal Specification QQ-S-711a for "Steel, Structural; (for), Bridges", Class C.

8-05. STEEL RAILS. - The rails for the trolley runway shall be Lorain Section 175-418. They shall be new and shall conform to the Standard Specification of the A.S.T.M. for "Open Hearth Steel Girder Rails of Plain, Grooved and Guard Types", Designation A 2-27 for Class A, No. 1 rails except that the lengths of all rails shall be in accordance with the design drawings. The rails shall be heat-treated uniformly throughout their entire length and cross-section to above the critical temperature, quenched and tempered to produce a Brinell hardness of 320 to 350. Heating, quenching and tempering shall be done with equipment which will accommodate the entire length of each piece. After heat-treatment the rails shall be smooth on the head, straight in line and surface and without any twists, waves or kinks.

8-06. CARBON STEEL FORGINGS. - Carbon-steel forgings shall conform to the Tentative Specification of A.S.T.M. for "Carbon Steel Forgings for General Industrial Use", Designation A 235-40T.

8-07. ALLOY-STEEL FORGINGS. - Alloy-steel forgings shall conform to the Tentative Specifications of the A.S.T.M. for "Alloy-Steel Forgings for General Industrial Use", Designation A 237-40T, Class E.

8-08. HOT ROLLED STEEL. - Hot rolled steel shall conform to the Standard Specification of the A.S.T.M. for "Commercial Quality Hot-Rolled Bar Steels", Designation A 107-40, Grades 3, 5, 6, or 7.

8-09. COLD-FINISHED STEEL. - Cold rolled steel shall conform to the Standard Specification of the A.S.T.M. for "Commercial Cold-Finished Bar Steels and Cold-Finished Shafting", Designation A 108-36, Grades 1 to 10.

8-10. BOLT AND NUT MATERIAL

(a) Unless otherwise specified or called for on the drawings, the material for bolts and nuts shall conform to the Standard Specification of the A.S.T.M. for "Commercial Quality Hot Rolled Bar Steels", Designation A 107-40, Grades 22, 23, 24, or 25.

(b) The material for bronze bolts and nuts shall conform to Federal Specification QQ-B-636 for "Brass, Naval, Bars, Plates, Rods, Shapes, Sheets, and Strips", Type I, half hard.

(c) The material for bolts and nuts of "high strength steel" shall conform to the Tentative Specification of the A.S.T.M. for "Alloy-Steel Forgings for General Industrial Use", Designation A 237-40T, Class D.

8-11. ROLLED STEEL WHEELS.

(a) The steel for the gantry and trolley wheels shall conform to the Standard Specifications of the A.S.T.M. for "Multiple-Wear Wrought Steel Wheels", Serial Designation A 57-39. The treads of the wheels shall be heat-treated to produce a Brinel hardness of 335 to 375. The

plate and hub of the wheels may show no appreciable hardness over the untreated condition, but the heat-treating process shall be such as to avoid the setting-up of internal stresses in the plate of the wheel. The contractor shall furnish the contracting officer with certified copies of charts showing the process for each heat-treatment of wheel material.

(b) The contractor may submit an alternate proposal for wheel material which may be approved by the contracting officer, provided the physical characteristics are comparable to those of the material specified above.

8-12. ROLLED STEEL ROPE SHEAVES. - The material for rolled steel rope sheaves shall conform to the Tentative Specifications of the A.S.T.M. for "Carbon Steel Forgings for Industrial Use", Designation A 235-40T, Class F.

8-13. CARBON STEEL CASTINGS. - Carbon steel castings shall conform to Federal Specification QQ-S-681a, for "Steel; Castings", Class a, except where shown otherwise on the drawings or called for in these specifications.

8-14. ALLOY STEEL CASTINGS. - Alloy steel castings shall conform to the Standard Specification of the A.S.T.M. for "Alloy Steel Castings for Structural Purposes", Designation A 148-36, Class B, Grade 2.

8-15. BAR AND MACHINE STEEL. - Bar and machine steel shall conform to the Standard Specifications of the A.S.T.M. for "Commercial Quality Hot-Rolled Bar Steels", Designation A 107-40, Grade 3, 5, 6 or 7.

8-16. GRAY IRON CASTINGS. - Gray iron castings shall conform to Federal Specification QQ-I-652 for "Iron, Gray; Castings", Class 35.

8-17. PHOSPHOR BRONZE. - Phosphor bronze for bushings, unless otherwise specified, shall conform to Federal Specification QQ-B-691 for "Bronze; Castings", and shall be "Composition 10".

8-18. SELF-LUBRICATING BUSHINGS. - Self-lubricating bushings shall be of the bronze and insert type, lubrite or equal.

8-19. HIGH TENSILE BRONZE. - High tensile bronze shall conform to the Standard Specification of the A.S.T.M. for "Manganese - Bronze Sand Castings", Designation B 54-39.

8-20. CORROSION-RESISTING STEEL. - Corrosion-resisting steel shall conform to Federal Specification QQ-S-763 for "Steel, Corrosion-Resisting; Bars and Forgings", Grade 6 with sulphur content of 0.18-0.35 percent with phosphorus .04 (max); and shall be free machining and suitable for threading and upsetting.

8-21. WELDING RODS AND DEPOSITED WELD METAL. - Welding Rods shall be of the heavily coated type. Filler metal shall have a corrosion resistance at least equal to that of mild structural steel. The ultimate strength shall not be less than 60,000 lb. per sq. in. and the elongation in two inches not less than 20%.

SECTION IX - WORKMANSHIP

9-01. GENERAL. - All work shall be performed in a thorough, workmanlike manner by workmen skilled in their various trades and shall be equal to the best modern practice in the manufacture and fabrication of materials and apparatus of the types covered by these specifications, notwithstanding any omissions from these specifications or drawings.

9-02. SHOP ASSEMBLY.

(a) The contractor shall assemble in the shop all unit parts, such as the complete trolley, except ropes; all gantry trucks with drive machinery; sheave blocks; and the operator's cab, complete with all controls, panels, and the like. All mechanical equipment shall be operated in the shop, after assembly, except such operations as may be specifically waived by the contracting officer. All field connections for the structural steel framework, mechanical, and electrical equipment shall be checked by shop assembling the component parts.

(b) All assemblies will be checked by the contracting officer. All interferences, errors in dimensions, and inaccurate workmanship discovered during the shop assembly shall be corrected. Before disassembly, each part to be shipped separately shall be matchmarked and identified in conformity with the erection drawings. Such marking shall be so done as to retain its legibility until field erection is completed.

9-03. PREPARATION FOR SHIPMENT.

(a) The contractor shall prepare all materials and articles for shipment in such manner as to facilitate handling and to protect them from damage, and shall be responsible for and make good any and all damages due to improper preparation or loading for shipment. Boxes or crates shall be marked and shall have a packing list inclosed showing the parts contained therein.

(b) Bearing surfaces of shafting and similar parts shall be covered with burlap or lagging. All electrical apparatus shall be crated or boxed. All pieces weighing more than five tons shall have the approximate weight painted thereon.

9-04. TOLERANCES. - Tolerances, fits, and finish shall conform, if explicit specification is lacking, with the best modern shop practices in manufacture of finished products of nature similar to those covered by these specifications. Like parts shall be interchangeable insofar as practicable.

9-05. ACCEPTANCE TESTS.

(a) After the gantry crane has been erected and placed in operating condition, it will be completely tested by and at the expense (except as noted below) of the Government to determine whether the requirements of these specifications have been fulfilled. All gantry crane operations

during these tests will be performed by one or more operators furnished by the Government and shall be under the direction of the contractor's erecting engineer. The services and all expenses of the erecting engineer shall be paid for by the contractor.

(b) The crane shall perform satisfactorily the following operations:

(1) Raise, lower, and hold in any position a test load of 260 tons, with the trolley in its extreme upstream position on the cantilever arms and with the gantry stationary over a gate opening.

(2) Raise, lower, and at the specified speeds hold in any position a test load of 225 tons with the trolley in position over either gate slot.

(3) Transport on the runway at the specified speed a test load of 165 tons with the trolley in any position between the limits shown for permanent gate operation.

Specifications: Long Sault Dam

SECTION X - PAINTS AND PAINTING

10-01. GENERAL. - All paint, when applied, shall provide a satisfactory film and a smooth even surface, and undercoats shall dry without excessive gloss, suitable for the proper application and adhesion of subssequent coats, as approved by the contracting officer. Where necessary, in the opinion of the contracting officer, to suit the conditions of surface, temperature, and weather existing at the particular time of application, the packaged paint may be thinned by the addition of not more than one pint per gallon of mineral spirits immediately prior to application, provided that in no case shall the viscosity of the paint be reduced to a point where the specified maximum coverages will be exceeded.

10-02. SURFACE CLEANING AND PREPARATION.

(a) Cleaning. - All ferrous surfaces to be painted shall be thoroughly cleaned of all loose millscale, rust, dirt, and other foreign substances to base metal by sandblasting, flame cleaning, or any other method approved by the contracting officer.

(b) Protection of Surfaces. - Care shall be taken to adequately protect all machinery parts, threads, and finished surfaces during cleaning and preparation.

10-03. PAINT APPLICATION.

(a) All painting shall be done in a neat, thorough, and workmanlike manner. Except where otherwise specified or specifically directed, all paint coats shall be applied by either brush or spray in such manner as to produce an even coating of uniform thickness completely coating all corners and crevices. All painting shall be done by thoroughly experienced workmen. Care shall be exercised during spraying to hold the nozzle sufficiently close to the surfaces being painted to avoid excessive evaporation of the volatile constituents and loss of material into the air. Paint shall be applied only to surfaces that are throughly dry and only under such combination of humidity and temperatures of the atmosphere and surfaces to be painted as will cause evaporation rather than condensation. A practical test is to wipe a damp cloth on the surface to be painted. If the moist streak dries promptly, conditions conducive to evaporation prevail. In no case shall any paint be applied to surfaces upon which there is frost or moisture condensation, or during rainy or misty weather, without suitable protection as approved by the contracting officer. Painting during unfavorable weather conditions shall be carried on under a protective covering.

While any painting is being done, the temperature of the surfaces to be painted and of the atmosphere in contact therewith shall be maintained at or above 50 degrees F. All paint when applied shall be approximately (within fifteen degrees of) the same temperature as that of the surface on which it is applied. Where protection is provided for paint surfaces, such protection shall be preserved in place until the paint film has properly dried and removal of the protection is authorized by the contracting officer. Working parts and hardware and other surfaces not required to be painted shall be cleaned and protected to the satisfaction of the contracting officer.

(b) Coverage. - The surface area covered per gallon of paint specified shall be not greater than 425 square foot per gallon.

10-04. PRIMING COATS.

(a) Unpainted Surfaces. - The surfaces of all non-ferrous metal-coated surfaces, machined surfaces, surfaces requiring welding, and surfaces which will be in riveted contact shall not be painted unless otherwise specified. All other ferrous surfaces, unless otherwise specified shall receive one priming coat of Synthetic Red Lead Primer.

(b) Structural Parts shall receive one shop priming coat.

(c) Machinery and Mechanical Equipment (except threads and finished surfaces) shall receive one shop-priming coat.

(d) Exterior Electrical Equipment shall receive one shop-priming coat, except that enclosing cabinets and cases shall be given two shop-priming coats on the inside and one shop-priming coat on the outside. All cast metal surfaces requiring painting shall be smoothly finished with an approved filler prior to the application of paint.

(e) Machined Surfaces shall immediately after final inspection be thoroughly cleaned of all foreign matter and coated with a heavy film of Rust Preventive Compound, U. S. Army Specification 2-84A.

(f) Screw Threads shall be protected by a coating of heavy oil.

10-05. PAINTS AND PAINT FORMULAE.

(a) General. - Paints shall have the composition as indicated below or as otherwise approved by the contracting officer. All paints, shall be guaranteed by the manufacturer not to gel, liver or thicken deleteriously or form gas in a closed container within a period of one year from date of manufacture.

(b) Processing of Paints.

(1) Except where otherwise specified or authorized, all paint shall be made by grinding together dry or paste pigments and a liquid vehicle to form a smooth paint that will flow freely and will not settle or react deleteriously in containers.

(2) Grinding shall produce a fineness such that coarse particles and skins will not exceed 1.5 percent (total residue left on No. 325 mesh screen, based on pigment). The grinding shall be done in a roll or pebble mill at temperatures that will not cause polymerization.

(3) Skinning shall be negligible after exposing 6 ounces of paint in a tightly closed 8 ounce glass container to sunlight for a total time of 24 hours.

(4) The resulting paint shall have satisfactory brushing and leveling properties, shall set to touch in not less than one hour nor more than four hours, unless otherwise specified, and shall provide a satisfactory film and a smooth even surface without undue gloss, suitable for proper application and adhesion of subsequent paint coats, as approved by the contracting officer. Sufficient suitable driers shall be added to make the paint dry hard within 18 hours.

(5) In view of potential variations resulting from variable processing equipment and technique, the manufacturer may be allowed, where necessary to produce the specified viscosities, to make slight changes in formula proportions, subject to specific approval of the contracting officer.

(c) Synthetic Red Lead Primer shall be composed of materials conforming, where applicable, to the specified requirements and mixed in the proportions as follows:

Red Lead	16.5% by weight
Iron Oxide	38.2%
Zinc Yellow	5.5%
Diatomaceous Silica	6.0%
Vehicle (see par.10-06)	28.0%
Thinner	5.8%

The paint shall have a consistency of flow of between 25 and 40 seconds through the 0.15 inch diameter orifice of a standard consistency cup when tested in accordance with the procedure specified in paragraph 9 and 10 of A.S.T.M., Specification D 33-37 for "Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels." It shall have satisfactory brushing and leveling properties, shall set to light touch in not less than 2 hours nor more than 5 hours, and shall dry hard for recoating in not more than 18 hours, when tested in accordance with paragraph P-2d of Federal Specification TT-V 81a, entitled "Varnish; Mixing (for) Aluminum Paint." The vehicle shall be a synthetic resin varnish consisting of a phenol formaldehyde resin with the necessary oils and volatile thinners to produce elasticity, water-proofness, adherence, and durability in the finished paint film. It shall meet the detailed requirements of paragraph 10-06.

10-06. PHENOLIC RESIN VARNISH VEHICLE SHALL conform to the following requirements:

(a) Oil-resin ratio shall be 33 gallons of oil to 100 pounds of resin.

(b) Shall be clear and transparent and entirely free from resin, estergum or other non-phenolic resins. Not less than 50 percent by weight of the vehicle shall consist of non-volatile oil and resin.

(c) The resin content shall be 100 percent para phenyl phenol-formaldehyde condensate similar and equal to Bakelite BR 254, and shall conform to the current U. S. Navy Department Specification 52R10 entitled "Resin Phenol-Formaldehyde."

(d) The volatile thinner shall contain not more than 80 percent mineral spirits and not less than 20 percent high flash coal tar naphtha or high flash hydrogenated petroleum naphtah and shall be free from toxic hydrocarbons such as benzol.

(e) Oil content shall be a ternary oil mixture composed of 40% linseed, [illegible] liquid oiticica, and 30% "Dehydrated" caster oil.

(f) The flash point shall be not below 30 degrees C. in a closed cup tester.

(g) Shall pass a Kauri Reduction Test of 120 percent, using the method described in paragraph F-2g, Federal Specification TT-V-81, for "Varnish; Mixing (for) Aluminum Paint."

(h) Shall show no skinning after 48 hours in a 3/4 filled, tight container.

(i) Flow-out films on tin plate panels dried 72 hours shall withstand immersion in cold water for 96 hours, and in distilled water at 200 degrees F. for 7 hours without showing more than slight haze which shall disappear within one hour, and shall show no other signs of deterioration. The panel shall be allowed to dry and cool for 15 minutes after removal from hot water and shall then be inspected for signs of failure.

10-07. PIGMENTS.

(a) Carbon Black shall conform to either Federal Specifications TT-B-601, entitled "Boneblack; Dry, Paste-in-Japan, Paste-in-Oil" or Federal Specification TT-L-71 entitled "Lampblack; Dry, Paste-in-Japan, Paste-in-Oil."

(b) Lead Titanate shall be similar and equal to Titanox "L" as manufactured by the Titanium Pigment Corporation.

(c) Red Lead shall conform to Federal Specification TT-R-191a (97) percent Grade for "Red Lead; Dry and Paste-in-Oil."

(d) Iron Oxide shall contain not less than 98 percent Fe_2O_3 and shall not contain any organic coloring matter.

(e) Diatomaceous Silica shall be an approved commercial grade.

(f) Zinc Yellow shall contain not less than 40 percent CrO_3. It shall be a basic zinc potassium chromate, soluble in acetic acid, free from lead compounds, and containing no added zinc oxide, and shall be stable or non reactive with the pigments and vehicles specified.

(g) Titanium Dioxide shall be similar and equal to either "Ti-Pure O" as manufactured by Krebs Pigment & Color Corporation or "Titanox NC" as manufactured by the Titanium Pigment Corporation.

10-08. THINNERS AND SOLVENTS.

(a) Mineral Spirits shall have the following properties:

Gravity - - - - - - - - - - - - - -43-47 degrees Baume
Flash Point (Closed cup)- - - - -100 degrees F. Min.
Initial Boiling Point- - - - - - 300-310 degrees F.
End Point- - - - - - - - - - - - 405 degrees F. Max.
A.S.T.M. Copper Strip Test- - - -Negative
Solvency (Kauri-Butanol)- - - - -41 cc (a) 77 degrees F.Min.

(b) Dependtine shall have the following properties:

	Maximum	Minimum
Specific Gravity at 15.5 degrees C.	0.854	0.845
Refractive Index at 20 degrees C.	1.477	1.472
Unpolymerized Residue (percent (38N H_2SO_4)	2.5	
A.S.T.M. Distillation Range:		
5% Distilling at- - - - - - - - - - - -	173 degrees C.	
10% Distilling at- - - - - - - - - - - -	175 degrees C.	
97% Distilling at- - - - - - - - - - - -	188 degrees C.	
Color-Lovibond 500 Amber - - - - - - - - -	3	
Appearance: Clear and free from suspended matter.		

(c) Toluol shall conform to U. S. Navy Department Specification 52T7 entitled "Toluene (Toluol)", except that it shall have a solvency (Kauri-Butanol Method) of not less than 100 cc at 77 degrees F.

(d) Xylol shall conform to A.S.T.M. Specification D364-36 for "Industrial Xylene (Xylol) or 'Solvent Naphtha'", except that it shall have a solvency (Kauri-Butanol Method) of not less than 93 cc. at 77 degrees F.

(e) Normal Butyl Alcohol (Butanol) shall conform to A.S.T.M. Specification D304-33 for "Butanol (Norman Butyl Alcohol)."

(f) Ethylene Glycol Monoethyl Ether shall conform to A.S.T.M. Specification D331-35 for "Ethylene Glycol Monoethyl Ether."

10-09. MISCELLANEOUS MATERIALS.

(a) Oil, Linseed shall conform to Federal Specification JJJ-O-331 for "Oil; Linseed, Boiled", or JJJ-O-336, for "Oil; Linseed, Raw", as specified or required.

(b) Insulating Varnish, U. S. Navy Department Specification 52-V-13b, entitled "Varnish; Insulating, (for) Electrical Purposes".

(c) Creosote Paint for surface treatment of timber shall conform to Federal Specification TT-W-561a, entitled "Wood-Preservative; Creosote (for) Brush and Spray Treatment."

(d) Ortho-Phosphoric Acid (H_3PO_4), shall be commercially pure product, in liquid form, containing not less than 75 percent H_3PO_4.

(e) Sodium Dichromate, ($Da_2CR_2O_7 \cdot 2H_2O$) shall be a commercially pure product in crystalline form containing not less than 85 percent $Na_2CR_2O_7$

10-10. INSPECTION.

(a) Unless otherwise specifically authorized, inspection of all materials for the paints and chemical rust inhibitor and the manufacture thereof, will be made by a representative of the contracting officer. All samples of materials and of the finished processed products will be tested and analyzed for conformity with the specifications by the Governemnt. The inspector will collect for testing, samples of each of the materials to be used in the manufacturing processes and will then seal the material containers until test results from the samples indicate that the various materials conform to specifications. He will witness the breaking of the seals on the approved material containers and the compounding of the materials for the product being manufactured, will collect samples of the finished product for testing, and will witness the placing, sealing, and labeling of the finished product in containers for shipment. After the finished products have successfully passed the prescribed test, shipment of the sealed containers will be authorized.

(b) In the case of ready-mixed and packaged paints of standard manufacture, other than those specified by tradename, the contractor shall furnish a sample in the standard stock package, together with a certified copy of the complete chemical analysis, for test and approval by the contracting officer.

10-11. Payment for all paint and painting will be included in the contract price for the respective metals or items painted.

ST. LAWRENCE RIVER PROJECT

FINAL REPORT 1942

LONG SAULT DAM ANALYSIS OF DESIGN

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APPENDIX III-22 (3)

S T. L A W R E N C E R I V E R

P R O J E C T

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F I N A L R E P O R T

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L O N G S A U L T D A M

A N A L Y S I S O F D E S I G N

CORPS OF ENGINEERS, U.S. ARMY

U.S. ENGINEER OFFICE - MASSENA, NEW YORK

July , 1942

PART I - LONG SAULT DAM, ANALYSIS OF DESIGN

PART II - LONG SAULT DAM, ESTIMATE OF COST

PART ONE

LONG SAULT DAM

ANALYSIS OF DESIGN

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ANALYSIS OF DESIGN FOR LONG SAULT DAM.

SECTION I - INTRODUCTION

1-01. This design analysis presents the general basis of design for the Long Sault Dam, a part of the development of the International Rapids Section of the St. Lawrence River. The detailed design of this structure had not been completed at the time this analysis was prepared, but sufficient information was available to determine the sections of the dam and of the adjacent earth dikes. Contract plans have been prepared which show the scheme of the river diversion and enough details of the dam itself to serve as a basis for the taking of contract bids.

It is expected that further design studies will be made and the detail drawings completed before contracts are let. A more complete analysis of the design will then be prepared.

1-02. DESCRIPTION OF PROJECT.

(a) The Long Sault Dam will be located just below the foot of Long Sault Island, crossing both the main channel of the St. Lawrence River and the smaller channel south of Long Sault Island. It will be located 4.0 miles north of the village of Massena, New York, and 6.5 miles west of Cornwell, Ontario, Canada.

(b) General Description of Dam. - The Long Sault Dam will be a concrete gravity structure having a maximum height of about 145 feet above foundation. It will have an overflow spillway flanked by concrete gravity bulkhead sections and earth wing-dams and earth dikes. The forty spillway openings will be controlled by vertical lift roller gates operated by means of two traveling gantry cranes. There will be a spillway apron and bucket built as a part of the spillway itself as the deep tailwater renders a stilling basin unnecessary. The crest length of the spillway will be 2,390 feet, of which length 2,000 feet will be clear spillway. The crest will be at elevation 221.0, twenty-one feet below the ultimate normal pool level of 242.0.

The concrete bulkheads at each end of the spillway will each be approximately 260 feet long. The wing dams and dikes will be of compacted earth, protected on both sides with stone.

(c) Purpose. - The long Sault Dam will serve as a control for the St. Lawrence River, developing the approximately 82 feet of drop through the Long Sault Rapids and spilling all flow which cannot be made use of at the powerhouses which are to be built near the foot of Barnhart Island.

1-03. PERTINENT DATA.

(a) Approximate principal quantities: (exclusive of Cofferdams)

Excavation, common	445,000 cu. yds.
Excavation, rock	180,000 cu. yds.
Concrete, all classes	642,000 cu. yds.
Earth fill	67,000 cu. yds.
Reinforcing	4,000 tons
Structural Steel	8,000 tons

(b) General Dimensions.

Maximum Height	146	feet
Length of Concrete Section	2,890	feet
Net Length of Spillway	2,000	feet
Length of Bulkheads	500	feet
Length of Earth Dike, South End - -	450	feet
Length of Earth Dike, North End - -	4,000	feet
Overall Length of Dam and Dikes - -	7,340	feet

(c) Spillway Control. - 40-50 foot vertical lift fixed-roller gates operated by means of two traveling gantry cranes and 18 fixed electric hoists.

(d) De-icing Provisions.

(1) Eighteen of the gates, opposite the deepest part of the river channel, are to be divided horizontally so that floe ice may be skimmed with lower section gate crests at elevations 229, 232, and 234. These 18 gates will have fixed individual hoists.

(2) All gate guides are provided with electric heaters and in the 18 split gates the sills of both halves are also provided with heaters.

(3) Each gate is to be provided with three air-bubbling orifices located in the dam crest just upstream from the gate, air to be supplied from a central air-pumping station. It is expected that this air system will be used continuously during severe winter weather.

(e) Elevations.

Top of Dam (Gate Platform)	261.00
Top of Spillway Gates	246.00
Top of Earth Dikes	254.50
Crest of Spillway	221.00
Maximum Pool	249.00
Normal Operating Pool (Final Stage)	242.00
Normal Operating Pool (Initial Stage)	238.00
Lowest Foundation Rock (Approximate)	115.00

Tailwater Elev. (220,000 cfs. over spillway)-170.4 (maximum)
Tailwater Elev. (220,000 cfs. through P. H.)-158.0 (minimun)

(f) Drainage Area. 298,090 sq. miles

(g) Area of Pool at Elev. 242.0 46,000 acres (Up to Iroquois Dam)

(h) Spillway capacity at Elev. 231.0 220,000 cfs.

Note: More complete hydraulic data is given in the Hydraulic Design analysis of this Project

1-04. INVESTIGATIONS. - The studies listed below are being made or will be made before the plans for the dam are completed. Insufficient data is available to warrant inclusion of any of these studies in this report, but the results of the studies will be made the subject of later reports.

1. Foundation explorations (borings and shafts)
2. Seismic explorations
3. Field compaction studies
4. Rock quarry tests
5. Foundation stress studies
6. Hydraulic model tests
7. Aggregate studies

Studies other than the foregoing are under consideration. Some of these studies relate to the particular conditions expected to obtain during construction of the Long Sault Dam, others, such as the measures to be taken to dissipate the heat-of-hardening of the concrete, will consist of digests of experience on other projects.

ANALYSIS OF DESIGN FOR LONG SAULT DAM

SECTION II - DESIGN LOADS

2-01. - The following excerpts from a memorandum dated February 14, 1941, from Mr. Guy A. Lindsay define the hydraulic conditions governing the design loading (a subsequent memorandum dated April 26, 1941 altered hydraulic conditions at Iroquois Dam but did not affect hydraulic conditions at Long Sault Dam):

2-02. CONDITION NO. I.

(a) Headwater Elevation to be such as to conform to second last paragraph of Engineering Report dated Ottowa, January 3, 1941: -

"All the works in the pool below the control dam shall be designed to provide for full Lake Ontario level but initially the pool shall be operated at maximum elevation 238.0."

The maximum monthly mean level of Lake Ontario at Oswego in nature was elev. 249.02 (May 1870). With present outlet conditions, and with 3,200 c.f.s. diverted at Chicago the maximum monthly mean level of the Lake would be elev. 249.66. Under Regulation of Lake Ontario (Method No.5) the resulting maximum monthly mean water level would be elev. 249.10.

Headwater level adopted.....Elev.249.00

(b) Tailwater elevation. - If headwater level is taken as full Lake Ontario level, then there can be no outflow from the Lake, in which case tailwater level should be taken at low water level of Lake St. Francis, say..... .. Elev.150.00

(c) Ice Pressure. - With extreme headwater and tailwater levels taken as above and in view of the fact that the maximum level of Lake Ontario would occur in the month of May, no ice pressure need be considered under Condition No. 1.

2-03. CONDITION NO. 2.

(a) Headwater elevation. - Maximum monthly mean headwater elevation resulting from application of Regulation of Lake Ontario (Method No. 5) and backwater studies described in Document No. 4 (Ottawa, November 15, 1940) would occur in May 1931 with a flow of 200,000 c.f.s., under which condition headwater level would be elev.242.3. To allow for future channel enlargement and as a factor of safety to cover differences in actual backwater slopes and those figured, it would appear that maximum operating headwater level should be taken at..... .... Elev. 245.00

(b) Tailwater elevation. - With maximum monthly mean headwater level resulting from operating conditions as above, all the flow would be going through the powerhouses and the tailwater level at the dam would be the same as tailwater level at the powerhouse. With 200,000 c.f.s. this level would be elev. 155.0 (Diagram 2326, Document No. 4). To allow for future channel enlargement, etc., it would appear that under these conditions tailwater level should be taken at.....Elev.154.00

(c) Ice Pressure. - With the above head and tailwater levels, ice pressure would be nil as this would occur in the open water season.

2-04. CONDITION NO. 3.

(a) Headwater elevation. The maximum monthly mean elevation under ice cover conditions, after the ice cover has formed over the pool extending from the Long Sault Dam to Iroquois, based on Regulation of Lake Ontario (Method No. 5) and the backwater calculations described in Document No. 4, would occur in January 1874 with a flow of 217,000 c.f.s. and would be elev. 238.5.

Full ice pressure might result under conditions as pertaining at the beginning of the ice forming period when the water level at the dam would be that resulting from open water friction losses only. The maximum water Level at the Long Sault dam under these conditions would be about elev. 242.3 (January 1st, 1862, Q = 221,000 c.f.s.).

To allow for future channel enlargement, it would appear that under these conditions the headwater level should be taken at .....Elev. 245.00

(b) Tailwater elevation. - Under conditions described in (a) above, there would be no flow over the dam and the tailwater level would be that at the powerhouse. This might be taken at.....Elev. 154.5.

(c) Ice Pressure. - Ice pressure under this condition should be taken at 10,000 lbs. per lin. ft. of dam acting at elev. 245.00 - 1.00 =.....Elv. 244.00

2-05. ST LAWRENCE WATERWAY

PRELIMINARY DESIGN DATA FOR LONG SAULT DAM

Condition	Headwater level	Tailwater level	Ice Pressure (10,000#/lin.ft.)
Long Sault Dam			
1	El. 249.00	El. 150.00	nil
2	El. 245.00	El. 154.00	nil
3	El. 245.00	El. 154.50	El. 244.00

Conditions Nos. 1 and 3 govern the design.

2-06. UPLIFT PRESSURES. - The Long Sault Dam has been designed for uplift pressures of full headwater at the upstream toe and full tailwater at the downstream toe both applied over two-thirds of the base area. Alternately it has been designed for full tailwater over the entire base plus a differential pressure equal to 50 percent of the difference between headwater and tailwater at the upstream toe dropping uniformly to tailwater only at the downstream toe. The first alternate is slightly more severe for the lower portion of the dam while the second alternate is more severe for that part of the dam which extends above tailwater level.

SECTION III - UNIT STRESSES

3-01. - The following unit stresses for concrete, reinforced concrete, and steel construction have been used in the design of the long Sault Dam.

3-02. ST. LAWRENCE RIVER PROJECT

Working Stresses for Concrete

Nature of Stress	3400 lb. Concrete Class A lbs/sq in	3000lb. Concrete Class B lbs/sq in	2400 lb. Concrete Class C lbs/ sq in
1. FLEXTURE			
a. Extreme fiber stress in compression	1225	1050	875
b. Extreme fiber stress in compression adjacent to supports of continuous or fixed beams or of rigid frames	1400	1200	1000
c. Extreme fiber stress in tension - Plain concrete only (to be used for massive sections such as monolithic arches, retaining wall, etc., not exposed to large temperature variations).	70	60	50
2. AXIAL COMPRESSION			
a. In short columns with lateral ties (banded columns)	785	675	560
b. In short columns with continuous spirals	980	840	750
c. Pedestals-Unreinforced-Gross Section	875	750	625
d. Composite Columns	875	750	625
3. BEARING			
a. Load over entire area	875	750	625
b. Load over partial area-Maximum permissible	1225	1050	875
4. COMBINED BENDING AND DIRECT STRESS-COMPRESSION IN EXTREME FIBER			
In no case should the section be less than that required where axial load alone is considered using stresses in 2-a and 2-b above.			

Working Stresses for Concrete (Cont'd)

Nature of Stress	3400 lb. Concrete Class A lbs/ sq in	3000 lb. Concrete Class B lbs/ sq in	2400 lb. Concrete Class C lbs/ sq in
4.(Cont'd)			
a. Spiral columns with entire section in compression	1225	1050	940
b. Spiral columns-Tension in section	1225	1050	875
c. Banded columns - Entire section in compression	1050	900	750
d. Banded columns-Tension in section (Short columns only, i.e.l/r = 40	1225	1050	875
e. Arches	1225	1050	875
5. SHEAR			
a. Beams-No web reinforcement nor special anchorage of longitudinal steel	70	60	50
b. Beams -No web reinforcement-Longitudinal bars specially anchored	105	90	75
c. Beams-Web reinforcement but longitudinal bare not anchored	210	180	150
d. Beams-Web reinforcement and longitudinal bars specially anchored	315	270	225
e. Flat slab-At critical section	105	90	75
f. Footings with hooked ends	105	90	75
g. Punching shear	260	225	190
h. Flat slabs-Beams at walls and openings-Torsional shear plus direct shear-Web reinforcement and longitudinal bars specially anchored	525	450	375
6. BOND			
a. Beams, slabs, and one-way footings			
Plain bars (where special) anchorage is provided)	140	120	100
Deformed bars	175	150	125
b. Two-way footings			
Plain bars	105	90	75
Deformed bars	135	115	95
c. Cold drawn steel wire	70	60	50

Classification:

1. Class "A" Concrete shall be used for pier houses , parapets, spillway birdge, deck girders, and as otherwise indicated.
2. Class "B" Concrete shall be used in the bridge piers, training walls, stilling basin or as otherwise indicated.
3. Class "C" Concrete shall be used for the mass section of the dam proper.

3-03. ST. LAWRENCE RIVER PROJECT

Working Stresses for Steel

Nature of Stress	Maximum Stress	Formula Used
1. TENSION		
Rolled Steel, on net section	18,000	
On the area of the nominal diameter of rivets under the limitations defined in Section 13	13,500	
Tension on reinforcing steel	18,000	
2. COMPRESSION		
Rolled Steel, on short lengths or where lateral deflection is prevented	18,000	
On gross sections of columns with a maximum of	15,000	$\frac{18{,}000}{1+\frac{L^2}{18000r^2}}$
For main compression members, the ratio L/r shall not exceed 120, and for bracing and other secondary members, 200		
3. BENDING		
On extreme fibers of rolled sections, and built-up sections, net section, if lateral deflection is prevented	18,000	
When the unsupported length L exceeds 15 times b, the width of the compression flange, the stress in pounds per square inch in the latter shall not exceed		$\frac{20{,}000}{1+L2/2000b^2}$
The laterally unsupported length of beams and girders shall not exceed 40 times b, the width of the compression flange.		
On extreme fibers of pins, when the forces are assumed as acting at the center of gravity of the pieces	27,000	
4. SHEARING		
On pins	13,500	
On power-driven rivets	13,500	
On turned bolts in reamed holes with a clearance of not more than 1/50 of an inch	13,500	
On hand-driven rivets	10,000	
On unfinished bolts	10,000	

Working Stresses for Steel (Cont(d)

Nature of Stress	Maximum Stress	Formula Used
On the gross area of the webs of beams and girders, where h, the clear distance between flanges in inches, is not more than 60 times t, the thickness of the web in inches	12,000	
On the gross area of the webs of beams and girders if the web is not stiffened where h is more than 60 times t, the greatest average shear per square inch, V/A, shall not exceed		$\frac{18,000}{1+h^2/7200t^2}$

5. BEARING

	Double Shear	Single Shear
On pins	30,000	24,000
On power-driven rivets	30,000	24,000
On turned bolts in reamed holes	30,000	24,000
On hand-driven rivets	20,000	16,000
On unfinished bolts	20,000	16,000
On expansion rollers per linear inch, of the roller in inches	600 times the diameter	

6. COMBINED STRESSES. For combined stresses due to wind and other loads, the permissible working stress may be increased 33 1/3 percent, provided the section thus found is not less than that required by the dead and live loads alone.

7. MEMBERS CARRYING WIND ONLY. For members carrying wind stresses only, the permissible working stresses may be increased 33 1/3 percent.

8. OTHER LOADS. For members carrying ice loads and other special loading the permissible working stresses will be as stated in the sections describing the structures involved.

ANALYSIS OF DESIGN FOR LONG SAULT DAM

SECTION IV - CONCRETE

4-01. SCOPE. - This section of the analysis of design deals with the factors affecting design of the concrete to be used in Long Sault Dam:

4-02. STRENGTH. - (28 day)

Class	Average for any 25 Consecutive Cylinders
A	3400 lbs. per sq. in.
B	3000 " " " "
C	2400 " " " "

Class "A" concrete will be used for the pier houses, parapets, spillway bridge, and otherwise as directed. Class "B" concrete will be used for the bridge piers, training walls, spillway apron, or otherwise as directed. Class "C" concrete will be used for the mass section of the dam. In the outer five feet of the exposed dam surfaces and around conduits and other openings, the Class "C" concrete may be enriched by the use of additional cement.

4-03. All cement will be of the moderate-heat-of-hardening type conforming to the requirements of Federal Specification SS- C-206a. It is estimated that a five-foot pour will reach its maximum temperature in about three days. The specifications will require that an interval of five days elapse between the completion of one pour and the start of the next pour. It will also be made possible for the contractor to use artificial cooling methods to reduce temperature changes.

4-04. AGGREGATE INVESTIGATIONS. - Extensive surveys have been made of the sources of fine and coarse aggregates in the vicinity of the project. The results of these surveys are described in detail elsewhere in this report. (Paragraph 12-03 (c)).

4-05. AGGREGATE CONTENT.

(a) General. - The total volume of aggregates to be used in each cubic yard of concrete will be that necessary to produce a dense mixture of the required workability. The individual mixes will be based upon securing concrete having suitable workability, density, impermeability, and the required strength, without the use of an excessive amount of cement.

(b) Sizes. - Course Aggregate will be graded and stored separately in 4 sizes, namely: a, 3/16" to 3/4"; b, 3/4" to 1-1/2"; c, 1-1/2" to 3"; d, 3" to 6".

(c) Tests.- Fine aggregate will be subjected to careful, thorough analyses to determine conformity with all of the foregoing and other specified requirements, including freezing and thawing and magnesium sulphate tests for soundness.

4-06. COARSE AGGREGATE. -

(a) Coarse aggregate may be washed gravel or crushed stone.

(b) Quality. - Coarse aggregate of standard quality will be required. An allowance is made for 5 percent of soft fragments, 1/4 of

1 percent clay lumps, and removal by decantation of 1 percent.

(c) Size. - For Class "A" concrete the maximum size aggregate shall be not more than 1½ inches; for Class "B" not more than 3 inches; and for Class "C" not more than 6 inches.

(d) Tests. - Both fine and coarse aggregates will be subjected to freezing and thawing tests and thorough tests to check their conformity with all requirements of the specifications.

4-07. MIXING WATER. - Reports from the U. S. Geological Survey indicate that St. Lawrence River water is satisfactorily free from injurious chemicals and ordinarily free from excessive amounts of suspended silt, etc.

4-08. PROPORTIONING. -

(a) It has been assumed that the three classes of concrete to be used would have the following cement content per cubic yard:

Class "A"	5.0 to 6.0 bags
Class "B"	4.0 to 5.0 bags
Class "C"	3.0 to 4.5 bags
Concrete deposited in water	6.5 bags

(b) Water Content and Consistency of Concrete. - In calculating the total water content in any mix, the amount of moisture carried on the surface of the aggregate particles shall be included. In all cases the amount of water to be used will be the minimum amount necessary to produce a plastic mixture of the strength specified and of the desired density, uniformity and workability. In general, the consistency of any mix will be that required for the specific placing conditions and methods of placement, and ordinarily the slump shall be between 1/2 inch and 2 inches for Class "B" and Class "C" concrete, and between 1-1/2 inches and 3 inches for Class "A" for "Method of Test for Consistency of Portland Cement Concrete," of the American Society for Testing Materials.

4-09. MIXING AND PLACING. -

(a) The contractor will be required to provide a complete modern and dependable mixing plant with a minimum capacity of 1200 cubic yards of concrete per 8 hours, equipped with automatic timers, weighing units, and means for measuring and indicating water entering the mixers.

(b) Placing. - Placing from bottom-dump buckets not exeeding 4 cubic yards in size will be required. Placing temperatures will be restricted to the range between 40 and 75 degrees (F). Artificial cooling or heating will be required when necessary. Thorough cleaning, dewatering and preparation of rock surfaces will be required before concrete is placed. Concrete courses in mass concrete are held to 5-foot maximum depth except near the crest of the dam. Initial courses and those placed after an interval of 15 days or more are restricted to a depth of 2 to 3 feet. Five days must elapse between the completion of one course before pouring can start on the next course. Special measures have been taken to terminate courses at details of discontinuity. Mechanical vibration of concrete is required.

4-10 CONSTRUCTION JOINTS. - Vertical construction joints, up to elevation 166.0 are to be formed with tongue and groove keys. Horizontal joints are to be continuous throughout all monoliths. Horizontal joints surfaces are to be cleaned and scrubbed before placing fresh concrete.

4-11. FINISHING. - Exposed concrete surfaces are to be given a smooth finish but rubbing with carborundum is not required.

4-12. ABSORPTIVE FORM LINING. - Absorptive form lining of approved type will be required on all permanently exposed formed concrete surfaces in order to insure a dense surface concrete. The present specification is modeled after that used for Caddoa Dam but provision is made for further investigation of this relatively new procedure.

4-13. EXPANSION AND CONTRACTION JOINTS. - Vertical expansion joints between monoliths are to be formed with vertical tongues and grooves with the outer edges of contact surfaces painted with asphalt. Waterstops will consist of a 6-inch diameter vertical channel halved by the joint and filled with plastic bituminous compound. A steam coil in each channel will serve to melt the filler, both during construction and later for maintenance. A copper strip will prevent the melted compound from reaching the face of the dam.

4-14. SEEPAGE DRAINS. - Vertical four-inch porous concrete tile drains are provided on six-foot centers near the upstream face of the dam. These drains will discharge into the inspection galleries, from which the seepage water will flow by gravity or be pumped to the tailwater below the dam.

ANALYSIS OF DESIGN FOR LONG SAULT DAM

SECTION V - DESCRIPTION OF DESIGN

5-01. SCOPE. - This section is intended to give a detailed description of the various features of design of the concrete section of the Long Sault Dam and reasons for the location and nature of these features.

5-02. DESCRIPTION. - The Long Sault Dam is of the gravity type, made up of an ogee overflow section with crest 2390 feet in length at elevation 221 MSL and with a training wall at each end of the stilling bucket. The spillway is controlled by forty 50-foot by 25-foot fixed roller gates. It is spanned by a reinforced concrete bridge supported on concrete-encased steel girders. This bridge serves to carry a highway and a railroad across the dam, while the outer girders support two traveling gantry cranes which will be employed to operate the spillway gates. At each end of the overflow section there will be a non-overflow bulkhead section 260 feet long. These non-overflow sections are keyed into earthfill dikes which extend for a short distance on either side of the concrete dam. The south bulkhead is of a standard gravity design while the north bulkhead has been modified in outline to provide compartments to be used for spare gate storage and repair, and for the electrical and mechanical services required in the operation of the dam. The dam is traversed from end to end by a service gallery and at a lower level by grouting and inspection galleries. Access to these galleries is had through adits and stairways from the guard houses located at either end of the dam and also through the two pier houses located at either end of the spillway section. The north pier house is also equipped with a combined passenger and freight elevator. A steel service platform runs from end to end of the spillway section under the bridge. This is intended to facilitate service and repairs to the electric and other conduits which will be located under the bridge. The mechanical design is such that all gates are interchangeable and any gate can be used as a stoplog in the slot above any service gate. The entire crest of the dam is supplied with air bubblers which are expected to keep the face of the gates free from solid ice even in the most severe winter weather. In addition to the air bubbler system electrical heaters are provided for the gate guides and sills of the split gates and for the guides only in the remaining gates.

5-03. GROUTING. - While the geological investigations indicate that the foundation rock under this dam will be sound and free from fissures, provision has been made for extensive and complete grouting. The specifications provide that the initial grout holes shall be widely spaced and that each shall be pressure tested. When there are indications that grout can be absorbed intermediate holes are to be drilled and tested. This process is to be continued until in extreme cases the grout holes may be 2-1/2 feet on centers. This will make certain that the entire dam foundation will be watertight for a depth of approximately 100 feet below the bottom of the concrete dam.

5-04. FOUNDATION DRAINS. - A system of foundation drain holes 30 feet on centers will be drilled just downstream from the grout curtain. These drain holes will extend up into the grout gallery where they will be fitted with means for measuring the actual hydro-static pressure. Any drainage

from the foundation will then be free to run from the grout gallery to the downstream face of the dam.

5-05. - CONCRETE DRAINS. - Porous concrete tile drains will be placed vertically on 6-foot centers near the upstream face of the dam to intercept any possible seepage through this face. They will drain into the same relief system provided for the foundation drains. These vertical drains will also serve to drain the galleries themselves and the vertical monolith joints.

5-06. GALLERIES. - The service gallery is located at elevation 203.0, well above the highest possible tailwater. It is intended not only for inspection purposes, but as a means of servicing the air bubbler system, electrical and other mains. Servicing access is provided from the service gallery to each of the vertical waterstops between the concrete monoliths. Each of the waterstops consists of a 6-inch diameter cylinder centered on the monolith joint. This cylinder is to be filled with melted bitumastic compound during construction. In order to insure the complete filling of the joint each waterstop is provided with a loop of steam pipe which will serve to melt the contents. This steam heating unit will terminate in the service gallery so that additional bitumastic compound may be pumped into the waterstop at any time and the entire waterstop reformed by heating in case the monoliths separate or settle out of line. The lower grout and inspection gallery will be located at elevation 166.0, which is above mean tailwater. This gallery is intended principally for grouting operations and for the drainage from both foundation drains and face drains. In the deeper part of the dam a supplementary gallery will extend from this elevation to a lower elevation suitable for grouting the deeper foundation. All galleries and stairways will be thoroughly ventilated and lighted.

5-07. BULKHEAD CHAMBERS. - The north bulkhead has been widened to provide room for the storage of two spare gates and for electrical and mechanical services. The gate repair bay is so designed that a gate under repair may be completely dismantled. Adjoining the gate repair bay is a room equipped with tools and facilities for mechanical repairs. The electrical bay will be a complete substation and control unit from which power will be distributed throughout the dam.

5-08. PIER HOUSES. - The two pier houses are intended to provide access from the roadway level to the various galleries and bulkhead compartments. The north pier house will be provided with a combined passenger and freight elevator while the south pier house will have only a stairway.

5-09. GUARDHOUSES. - Small double guardhouses are provided at each end of the dam in order to insure complete control of access to the structure and to the galleries traversing it.

5-10. TRAINING WALLS. - A training wall is provided along each side of the spillway. The training walls are made only high enough to supply 5 feet of freeboard above high tailwater elevation. Estimates were made for gravity, counterfort, and cantilever walls and the counterfort design adopted on the basis of these estimates. The walls are to be thoroughly drained so that they will not be subject to extreme conditions of loading.

ANALYSIS OF DESIGN FOR LONG SAULT DAM

SECTION VI - STRUCTURAL DESIGN

6-01. SCOPE. - This section describes the stress analysis procedure adopted, assumptions made, and methods employed to determine the design for the various parts of the dam. Much of the design procedure to be described has not at this time been carried out and it is the intention to describe it here only as a guide to the future complete design of this project.

6-02. COMPUTATIONS. - The computations which have been made a part of this report are based on simple two-dimensional mechanics, which are sufficiently accurate for a dam of this type and size. The unit stresses are based on the simple formula

$$P = \frac{P}{A} \pm \frac{Mc}{I}$$

P = total vertical force on the section
A = Area of the section
M = Bending moment acting on the section
c = Distance of face from neutral plane
I = Moment of Inertia of section = Ak^2 when k is the radius gyration of the section

6-03. PRINCIPAL STRESSES. - It is intended to plot the "principal stress" diagrams for all sections of the dam in order to arrive at a more accurate basis of design for reinforcement in the vicinity of the gallery and adits. Reference is made to paper 1847, proceedings of the American Society of Civil Engineers, "Determination of Principal Stresses in Buttresses and Gravity Dams," by W. H. Holmes. The detailed application of this method is described in the Analysis of Design Report for the Caddoa Dam.

6-04. - SPILLWAY BRIDGE. - No detailed design has been made for the spillway bridge, but sufficient investigation was made to establish the probable maximum size of girders and thickness of slabs. Maximum live loads assumed were:

(a) On slabs, a 240,000 pound gate supported on the slab, causing a loading of 4800 pounds per foot width, concentrated at mid-span; plus impact of 25 percent.

(b) On railroad girders, E 70 locomotive loading. Impact according to the usual A. R. E. A. formulas for this length span would be about 90 percent, but since this is a service railroad on the roadway birdge of a dam it was assumed that trains would be operated only at low speed. Impact allowance used was 25 percent. No highway live load was used with the maximum railroad loading but the highway portions of the structure are designed for H-20 loading.

(c) On the downstream crane girder, loading from one four-wheel crane truck with 86 kips per wheel, plus one-half of an H20 truck, from the highway, plus impact of 25 percent of both live loads. The upstream crane girder would have approximately the sametotal load, the dead load being greater but the highway live load being omitted.

6-05. EARTH PRESSURES. - The physicial properties of earth fill were assumed as follows:

Dry Weight	= 110 lb/cu. ft.
Specific Gravity	= 2.65
Void ratio	= 0.5
Angle of Internal Friction (Angle of repose) ϕ	= 33°
Sin ϕ	= 0.5446

Applying Rankines: well-known equation

$$P = \frac{wh^2 (1 - \sin \phi)}{2 \quad (1 + \sin \phi)}$$

the following horizontal pressures were thendetermined and used:

Dry Earth (liquid equivalent)	= 32.5 lbs/cu. ft.
Saturated earth and silt	= 82.5 lbs/cu. ft.

6-06. DESIGN OF PIERS. - The spillway piers are of comparatively slender proportions. They will be heavily reinforced with a structural steel framework shaped to insure accurate forming of the pier itself and support for the gate guides. This structural framework will be supplemented with a system of bar reinforcement. The piers will be designed to support not only the maximum normal reaction of the gates, including ice pressure, and the balanced and unbalanced reactions from the bridge and gantry cranes, but also for twisting loads and hydrostatic loads due to partial gate closure. Reinforcing will be carried down into the mass of the dam well below the level of possible tension on the pier monoliths.

6-07. REINFORCING. - It is intended to use reinforcing in all pier and spillway monoliths wherever the computations indicate that tension may occur.

6-08. CONTINUITY. - In order to facilitate construction operations the bridge girders are designed as simple spans with the concrete encasement not used as a reinforcing element for the steel work. This design tends to eliminate bending in the piers due to transferred moments. The structural framing of the pier houses, guard houses, and north bulkhead will be of rigid frame type.

ANALYSIS OF DESIGN FOR LONG SAULT DAM

SECTION VII - SPILLWAY GATES

7-01. CHOICE OF TYPE. - Forty-two gates are provided for the 40 spillway openings, two being spares. Eighteen of the gates are split horizontally in two sections. The vertical lift type was selected for the following reasons:

(a) When a gate is lifted, the spillway opening is left clear for passage of ice.

(b) It was desired to provide crests at various elevations in some of the spillway openings for skimming ice.

(c) In event of damage to a gate, a spare gate may be used in the emergency slot in the same opening while the damaged gate is being repaired.

(d) When piers and appurtenances are taken into account, the vertical lift gate is no more costly (for this type of dam) than any other type of gate would be.

The cantilevered wheel design was chosen in order to keep the depth of slot at a minimum and to eliminate the need for end rollers.

7-02. LOADS AND UNIT STRESSES. - The loading criteria adopted were:

Condition (I) Headwater at Elevation 249 with no ice pressure. The top of gates was set at Elevation 246, which allows one foot of freeboard above the assumed maximum operating level. Hence this condition of loading corresponds to a 3-foot depth of flow over the gates. Elevation 249 is the maximum possible water level with all flow in the river shut off.

Condition (II) Headwater range between Elevation 231 and Elevation 245.5 plus a uniform ice pressure of 10,000# per lineal foot of gate distributed over four feet vertically and corresponding in range to the headwater elevations. Thus, ice pressure was figured between Elevation 227.5 and Elevation 246.0.

The allowable unit stresses in structural steel used for Condition (I) correspond to a basic unit stress of 18,000 lbs. per sq. in. in bending for structural carbon steel and 24,000 lbs. per sq. in. for structural silicon steel. The thickness of all material under computed stress has been increased 1/16" over design thickness as an allowance for corrosion.

The allowable unit stresses used for Condition (II) have been increased 25% over those for Condition (I) and no allowance made for corrosion.

A minimum material thickness of 3/8", except for fillers, was adopted.

For Condition (I) a radial load of 180,000 lbs. was allowed on each gate wheel in combination with a side thrust of 70,000 lbs. at the tread. For Condition (II) the allowable loads on the wheel were increased 25% over those for Condition (I).

Tailwater was not considered because it will be below the gate sill for both conditions.

The weight of water was considered as 63.5 lbs. per cubic foot.

7-03. STRUCTURAL DESIGN. - The gates will be mainly of structural carbon steel and of riveted construction except for calking and minor details where welding may be used. The water load will be carried by the skin plates and stiffeners into horizontal girders which frame into the vertical end posts containing the axle bearings. Since vertical diaphragms and connections are unusually heavy to distribute ice loads and to take the dead load of the gate in handling, diagonal bracing will not be used. The end posts will be of silicon steel.

7-04. SEALS.-

(a) Side seals. - The seals at the sides of each gate section are 2½" diameter staunching rods of corrosion resisting steel fastened to the gate body by tobin bronze bolts. Proper allowance was made for tolerances in guides, track rails, gate structures and wheels in determining the movement of the seal in a direction parallel to the face of the pier. The sealing strips are placed on the downstream edges of the gate slots and water pressure on the upstream side of the gate will increase the pressure between the seal and seal strips.

(b) Bottom Seals. - (1) Bottom seals of the top section of the double section gates are of fabric-reinforced synthetic rubber and are clamped to the bottom of the gate sections by structural steel clamp bars and steel bolts with tobin bronze nuts and spring lock washers. Junction with the side seals is made with synthetic rubber blocks clamped and compressed against the gate members and the bottom seal to form water-tight joints.

(2) Bottom sealing of all gates is secured by bearing of the planed steel surface of the gate on the babbitt metal in the sill.

7-05. WHEELS. - The wheels will be of rolled steel, 30" in diameter, with heat-treated treads and roller bearings. A centralized pressure greasing system will provide lubrication for the wheel bearings at each end of each gate section.

The wheels will run on heat-treated crane rails set vertically in the slots. Sufficient slip on the axles to allow for changes in gate length due to temperature and for tolerances is provided.

7-06. HOIST. - Each double-section gate opeing (designated Nos. 21 to 38 inclusive on the drawings) will be equipped with fixed hoists for independent operation of the gates. The hoists will be similar to and of the same capacity as those on the crane trolleys and will be mounted on structural steel towers with bases on the pier tops. The hoists will be made so that they may be removed from the towers by either of the gantry cranes in order to permit removal of the gates from the slots.

7-07. LIFTING AND COUPLING MECHANISM. - The lifting and coupling mechanisms for the double section gates will consist of alloy steel castings and structural silicon steel connection bars. They are designed each as a double hook engaged by a pair of swinging arms, hinged from a cross head. One hook is fastened near each end of the top of the lower gate section. Normally these hooks are engaged through the swinging arms and cross head, with a tie bar extending through the upper gate section.

These tie bars terminate in a second pair of double hooks. When lifting the two sections together, the lifting blocks of the hoists (or the swinging arms of the lifting beams) engage the upper hooks, lifting the lower gate section through the tie bars and lower hooks. The upper gate section rests upon the lower section. The upper and lower sections are connected together through the tie bars which are held in locked position by wedges near the upper ends bearing against the top of the upper gate section.

The wedges are electrically operated near the top of each double section gate by a motor-driven screw mechanism with manual auxiliary. The wedges will connect the two sections and permit their operation as a unit. Manual emergency operation of the links is also provided for.

Each single section gate is provided with a pair of guide sockets for centering the lifting bean. Each top section of the split gates is provided with a pair of guide sockets at the top and a pair of vertical tapered pins at the bottom. The lower sections are provided with a pair of guide sockets at the top. The vertical tapered guide pins have only sufficient clearance in the sockets so the lifting link will engage the hooks freely.

7-08. PROTECTION AGAINST ICE. - Ice protection for the upstream face of the gates will be furnished by an air bubbler system with outlets near the sills and supply pipes in a gallery under the spillway. Provision for preventing or melting ice in the gate slots is made by installing electric heaters in the piers. These heaters are each of 4 kw capacity and are encased in 3½" standard black steel pipes embedded in the concrete.

Each service slot will be provided with 4 casings and electric heater units installed.

Each emergency slot will be provided with 3 casings and electric heater units will be taken from the service slot casings and installed for operation when necessary.

Ordinarily only the double section gates will be operated during the freezing months of the year and the operation of these gates is sufficient to maintain a regulated flow of water. Complete ice protection is provided for these 18 gates by the use of 10 kw of electric heaters placed adjacent to the meeting sill and ten kw placed close to the bottom sill of each gate. These sill heaters are intended to melt ice formed by leakage through the sills and each element is enclosed in a heat-insulated designed to direct the heat to the desired points of application.

Each double section gate is thus provided with a total heater capacity (in sills and guides) of 52 kw or 1 kw for each 24 square feet of gate area. It is believed that this relatively large amount of artificial heat, combined with the air bubblers and insulated end posts, will insure ice-free conditions in the severest weather.

Since the main body of the gate on the downstream side is not sheathed, the vertical chamber at each end formed by the end post, the end diaphragm and the skin plate is covered on the downstream side by removable steel plates and the inside of the chamber insulated by a compound of asbestos and asphalt. This construction is intended to insulate the water in the gate slot from the air on the downstream side of the gate and thus tend to lessen ice formation about the wheels.

7-09. OPERATION. - The gates will be operated by either of the two traveling gantry cranes, or by fixed hoists, which are placed only at the double section gate openings. Ordinarily the double section gates will be operated as a unit. When it is necessary to skim ice the two sections will be disconnected and the top section raised. The gates will be held in open position by means of retractable dogs which have been designed as cantilevers resting on structural steel grillage bases embedded in the pier concrete. These dogs deliver a vertical reaction into the piers and act as simple supports for the gates. A pair of dogs, at elevation 251.62, is located in each opening at the service slots and, in the double section gate openings, in the emergency slots, also. The dogs are individually hand operated at the deck level by levers, and support the gate on the treads of the over-hung wheels. The dogs in each gate opening are designed to support a load of 150% of the weight of the gate in air.

In case of damage to a gate in the service slot, one of the two spare gates may be lowered in the emergency slot, upstream, and the space between the gates unwatered to permit work on the damaged gate to be done in the dry. Clearance is provided so that this spare gate can be carried into place from either end of the dam.

In cold weather the air bubbler system will be kept in operation constantly to prevent ice formation in front of the gates. The heaters in the slots will be run at partial load to prevent ice forming, or will be turned on to melt ice already formed before the gates are operated.

ANALYSIS OF DESIGN FOR LONG SAULT DAM

SECTION VIII - GANTRY CRANES

8-01. LOADS, UNIT STRESSES AND SPEEDS.-

(a) Two traveling gantry cranes are provided for the operation of the spillway gates and gates used for diversion. The 260 ton capacity of the main hoist for Crane No. 1 was determined by the pull required to lift the heaviest diversion gate under full water load, plus the weight of the lifting bean. The capacity of the main hoist for Crane No. 2, which is not used for diversion gate operation, is 175 tons. This is the maximum load expected for spillway gate operation. The capacity of the auxiliary hoist on each crane was set at 10 tons, that being considered safe maximum weight of any movable equipment on the dam except the gates.

(b) The following loading conditions were considered:

(1) For gantry in operating condition, dead load + live load + impact + tractive force + 10 lb. per sq. ft. wind load.

(2) For gantry in static condition, dead load + live load + 30 lb. per sq. ft. wind load. (for handling spillway gates only)

(3) For gantry in operating condition, dead load + live load + collision.

(4) For gantry in operating condition, dead load + breakdown torque of hoist motor acting through one drum.

(5) For gantry in static condition, dead load + 40lb. per sq. ft. wind. (for stability only)

(c) Condition 1 is considered a normal operating condition. For conditions 2 and 3, unit stresses 25% in excess of those for condition 1 may be used. For condition 4 unit stresses up to 90% of the elastic limit of the materials involved are allowed. Condition 5 must show a factor of safety against overturning of at least 2.

(d) The allowable unit stresses for condition 1 conform to the American Institute of Steel Construction's Specification for the Design of Structural Steel for Buildings, revised 1936, except that all stresses are proportionately reduced in the ratio of 16,000 to 20,000 for spillway gate operation. For diversion gate operation, the 20,000 pound per square inch base may be used.

(e) Speed of operation is not considered of prime importance in handling the gates, hence gantry travel, trolley travel and hoisting speed are moderate. The speeds adopted are as follows:

Gantry travel	75 feet per minute
Trolley travel	15 feet per minute
Main Hoist Speed	2 feet per minute
Auxiliary Hoist Speed	15 feet per minute

8-02. DESIGN

(a) Each gantry frame is rectangular in plan with the trucks skewed to follow the curved tracks. The portals are designed as rigid frames hinged at the rail heads and the side frames are braced diagonally. The operator's cab and access ladders are located on the downstream side of the crane. The cab is designed to give the operator a plain view of the runway and of the gate as it enters the slot. The trolley and track are completely enclosed by a sheet steel housing.

(b) On Crane No. 1 only, the trolley runway and housing is extended upstream in order to reach the diversion gates with the main hoist. This crane is equipped with a gasoline-electric auxiliary power unit.

(c) The cranes were designed with a view to making the exterior appearance as pleasing as possible. Long horizontal louvres in the trolley housing, curved gusset plates, and covers over the gantry trucks and drive motors are some of the features intended to improve the appearance of the structure.

(d) The two main hoist drums are mounted on a single trolley and are spaced so that the sheave blocks are directly above the hooks on the gates when the crane is centered over a gate opening. The auxiliary hoist is mounted between the main hoist drums and is equipped with a single crane hook. The main hoist sheave blocks are connected to moving cross heads in a lifting beam, and swinging links at the bottom of each cross head engage the lifting hooks on the gates. The lifting beam is guided by the rails in the gate slots.

(e) All motors are of the wound rotor type and are equipped with electric shoe-type brakes. Each gantry truck is driven by an individual motor concealed at the inner end. The main hoist drums are driven by a single motor on a flexible-coupled shaft.

8-03. OPERATION

For permanent operation, each crane is used to lift or lower the spillway gates under full water load, to move them in an up-and-downstream direction within the limits of the trolley travel, to transport them along the curved runway over the spillway and north bulkhead, to handle the removable fixed hoists, and to perform miscellaneous service on the dam. Crane No. 1 will be used temporarily for raising and lowering the river diversion gates and to transport them along the face of the dam with the trolley stationary on the cantilever arm. The normal power take-off for both cranes is from conductors in a continuous slot in the upstream side of the spillway bridge.

ANALYSIS OF DESIGN FOR LONG SAULT DAM

SECTION VIII A

FIXED HOISTS

8A-01. LOADS, UNIT STRESSES AND SPEEDS. -

(a) The eighteen fixed hoists for operation of the gates in openings 21 to 38 inclusive are each of 175 ton capacity at the lower sheave blocks.

(b) The loading conditions considered are:

(1) Dead load - live load - 30lb. per square foot wind load on the projected area of hoist and towers.

(2) Dead load - 40 lb. per square foot wind load on the projected area of hoist and towers.

(3) Dead load - breakdown torque of the hoist motor acting through one drum.

(c) Because the hoists may be operated by remote control, the allowable unit stresses are lower than those for the gantry cranes under comparable loading conditions. For the hoists, the unit stresses allowed for both Conditions 1 and 2 conforms to the American Institute of Steel Construction's Specifications for the Design of Structural Steel for Buildings, Revised 1936, except that all stresses are proportionately reduced in the ratio of 16,000 to 20,000. For Condition 3, unit stresses up to 80% of the elastic limit of the materials involved are allowed.

(d) A hoisting speed of one foot per minute was selected in order to keep impact stresses and power requirements low. A single gate may be opened at this speed in about 27 minutes, which is considered satisfactory.

8A-02. DESIGN. -

(a) The hoists consist of a pair of plate girders supporting the hoisting machinery and resting on steel towers anchored to the pier tops. The entire hoist unit is removable from the towers by means of one of the spillway gantry cranes. It is necessary to remove the hoist from the towers in order to remove the gate from the slots.

(b) The hoists and towers are completely enclosed by sheet steel with details arranged to make the appearance of the structures harmonize with that of the gantry cranes.

(c) The two hoist drums are driven by a single squirrel-cage motor and the lower sheave blocks are connected directly to the lifting hooks on the gates.

8A-03. OPERATION. -

In case of shut-down of the powerhouse it is necessary to open spillway gates immediately. Hence the control for the hoist motors is so arranged that any hoist may be operated either from the powerhouse or from a control panel on the dam. The hoists may be started consecutively at time intervals only long enough for the starting current on any hoist motor to drop to normal after the gate is in motion. Thus all 18 gates may be opened in approximately 30 minutes.

ANALYSIS OF DESIGN FOR LONG SAULT DAM

SECTION IX - DIVERSION GATES AND APPURTENANCES

9-01. GENERAL. - Drawing BD-1-30/1 shows one diversion plan which involves the temporary use of 18 of the spillway gates during diversion. The concrete pier monoliths are to be carried up to full height and the deck placed so that one gantry crane can be operated over the south end of the dam, out as far as Pier 20. Operating slots are provided in the pier nosings and the overflow section is shaped to permit sealing of the gate sills. With one complete gate section temporarily attached to a part of one of the 18 split gates a gate can be formed large enough to cover the diversion opening. These gates can be operated to permit completion of the overflow monoliths without adversely affecting navigation.

These eighteen diversion openings can take care of the entire flow of the St. Lawrence River during the construction period prior to the time the pool is to be raised. During diversion the pool will at no time be raised to a level that would interfere with navigation.

9-02. LOADS AND UNIT STRESSES. - The gates are designed for normal operating conditions as noted in paragraph 7.02. When the gates are used for diversion the allowable stresses will be increased to 150% of those allowed for condition I, paragraph 7.02, or 80% of the stresses at the yield point of any material. The allowable wheel load will be increased to 275,000 pounds.

9-03. ALTERATIONS TO SPILLWAY GATES. - In order to use the spillway gates for diversion it is necessary to build a seal at the sides and bottom on the skin plate side. This seal is of continuous molded rubber of circular section backed by an air base and contained in a slot formed by two channels. The sealing face will be far enough from the skin plate to permit placing of concrete forms between the face of the dam and the gate.

After river diversion operations are complete the temporary seals will be removed and the gate sections uncoupled for use on the spillway.

9-04. OPERATION. - The gates will be operated by one of the permanent spillway gantry cranes which will be equipped with cantilever extensions of the trolley tracks upstream. In operating the gates for pool regulation, one or more gates at a time are to be sealed and downstream bulkheads placed so that an opening can be dewatered. After fifteen feet of concrete has been placed, the gates will be raised, as described above, to allow passage of water beneath them while closure is made in another group of openings. After the bottom of all the openings has been raised in this manner the first group of gates will be again lowered to the bottom of the openings and another fifteen feet of concrete poured behind them. This procedure will be carried on until the spillway sections in the diversion openings have been completed. The air hose back of each seal is deflated

before the gate is moved and is inflated to provide sealing pressure after the gate is in place.

Temporary retractable dogs are located in the pier noses to permit holding the gates at proper elevations for pouring concrete and for passing the flow of the river beneath the gates. The dogs are hand-operated from the pier tops.

ANALYSIS OF DESIGN FOR LONG SAULT DAM

SECTION X - ELECTRICAL DESIGN

10-01. PRIMARY SYSTEM. - Power is available from the Station Service Bus in the powerhouse, approximately 4 miles from the dam load center. The bus voltage will be 6600Y, and as this is a good voltage in this case for transmission, it was chosen in the interest of simplicity, reliability, and low cost. Two double circuit lines will be provided in order to safeguard continuity of service. Wood pole lines will be used, low sheltered routes will be taken as much as possible, overhead ground wires will be provided, and lightning protection in general will be given special consideration. Limiter reactors will be provided at the connection to the Station Service Bus in the powerhouse so that faults on these lines will have comparatively small adverse effect on the bus service. Surge absorbers will be provided to protect the cable and equipment at the dam from destruction due to direct lightning strikes on the overhead lines.

10-02. ELECTRICAL SUBSTATION. - The voltage will be stepped down from 6600 volts to 460 volts by three 3¢, 500 KVA network transformers operating in parallel and located in an electricalbay in the north bulkhead of the dam. The added cost of this system over a single three phase 1500 KVA bank is considered justifiable in the interest of reliability.

10-03. SECONDARY NETWORK. - Due to the large number of diverse, 3¢, 480 volt loads, the large amount of power involved, the reliability required, and the fact that it is not economical to use extremely large conductors, the secondary network is at the same time the most reliable and economical system of distribution in this particular case. By the use of a network, the large current carrying capacity in the cables required for the occasional sumultaneous operation of the eighteen individual operator hoist gates will be used to advantage to keep the normal voltage regulation and power loss very low.

10-04. FIXED HOISTS. - There will be eighteen gates operated by fixed hoists. These hoists will be operable from the powerhouse as well as from the deck above each gate. Each hoist will have a single high torque squirrel-cage induction motor with a thrustor type brake. Remote indicating gate position indicators will be provided with the indicators located in the powerhouse.

10-05. GANTRY CRANES. - Each of the two gantry cranes will have a wound rotor induction motor for hoisting, four motors for traveling, a trolley travel motor, and an auxiliary hoist motor, all wound rotor induction motors. Interlocks will be provided to limit operation to one motion at a time, so that only the travel motors need to be considered where power requirements are concerned, since they make up the large load. Power will be collected from a three phase bus located in a recess in the upstream face of the dam. The collector conductors will be supplied from the secondary network at four points. Sectionalizing breakers will be provided between each connection to limit faults to approximately one fourth of the length of the dam. One of the cranes will be provided with a standby gasoline engine generator set.

10-06. GATE HEATERS. - Each of the 40 gates will be provided with eight 4 KW, 3¢, star connected vertical riser heaters to keep the gate guides free of ice. 50% of full heat will be obtainable by opening one leg of the star

connected heaters. In addition, two 10KW heaters will be provided for each of the eighteen split gates to free the seals. All heaters will operate on 460 volts, and power will be taken from the secondary network.

10-07. MISCELLANEOUS EQUIPMENT. - The elevator, sum pumps, and air compressors for the bubbler system will operate on 460 volts, 3¢, and will be supplied from the secondary network.

10-08. LIGHTS. - There will be four 25 KVA, 480/120-240V., lighting transformers, located to keep all secondary circuits reasonably short. Power to the primaries will be taken from the secondary network. Each crane will be provided with a 480/120-240 V., lighting transformer, for supplying its own lighting requirements from the 480 V., 3¢ power supply.

(a) Roadway Lights. - 100 Watt roadway balustrade lights will be located every 30 feet on alternate sides of the roadway, providing average illumination of approximately 1/2 ft.-c. These lights will be connected in four 15-ampere, 3-wire branch circuits, and will be controlled by means of magnetic switches and an automatic time switch.

(b) Interior Lighting. - The machine shop, electrical bay, and other places in which work is to be done will be illuminated to approximately 10 ft.-c, with fluorescent lights. The interior of the pier-houses and guardhouses will be illuminated to approximately 5 ft.-c.

(c) Display Lighting. - Each spillway will be illuminated by a 1000 Watt floodlight, located under the roadway, halfway between piers. All display lights will be controlled together from a central point by remotely controlled magnetic switches.

10-09. INTER-COMMUNICATING TELEPHONE SYSTEM. - A complete inter-communicating telephone system will be installed to provide communication between several stations on the bridge deck, the electrical substation, the gate repair bay, and the powerhouses. Stations will be provided at every fourth pier with howlers to attract the attention of the crane operators.

10-10. SERVICE BRIDGE. - A bridge will be provided through-out the length of the dam supported from the underside of the roadway. It will provide support for and access to electrical conduits and other equipment. Access to the bridge will be provided from the north bulkhead and the south pier house. Hatches at every fourth pier will provide access from the roadway.

ANALYSIS OF DESIGN FOR LONG SAULT DAM

SECTION XI. - STABILITY

11-01. GENERAL. - Stability of the various sections of the Long Sault Dam was determined by the application of loadings due to cases 1 and 3 with uplift pressures assumed as described in Section II. Each foot of the spillway section is in itself stable but, due to the heavy reactions of the gates, the pier sections were computed as monoliths 20 feet wide (below the spillway crest.). The plan of diversion permits the building of the pier monoliths to 20-foot width only and as the vertical expansion joints effect a complete severance of the monoliths, except for the doubtful value of the tongue and groove joints, it was necessary to insure complete stability for a 20-foot pier monolith, not only during construction, but after the completion of the dam.

11-02. MONOLITHS. - One diversion plan under consideration would require that 18 bays at the south end of the dam be built with 40-foot spillway monoliths and 20-foot pier monoliths, the river being diverted between the piers, which would support temporary bulkhead gates, operated to permit the gradual raising of the spillway monoliths. Another diversion plan would require that an orifice 40 feet wide be left at the center of the spillway monolith in eight or more bays at the south end of the dam. Either plan would require the stability analysis of the dam on the basis of 40-foot spillway and 20-foot pier monoliths with the pier monoliths built to full height initially and the spillway monoliths brought up in stage to final crest elevation.

11-03. APPLICATION OF LOADING. - As noted under Paragraph 2-06, two possible uplift conditions were studied. All sections of the monoliths were checked for stability at various elevations for both conditions and where gravitational stability was lacking it was determined that the small amount of tension on the upstream face of the pier and spillway monoliths could be taken by a moderate amount of steel reinforcement.

11-04. SHAPE OF SPILLWAY. - The shape of the spillway was determined by the requirements of stability in the upper portion of that monolith rather than by optimum hydraulic shape for normal pool levels. The shape used, as outlined by XI. $82 = 32.53Y$, would be the lower boundary of the nappe for a pool elevation of 251.0. However, even with the slightly reduced hydraulic efficiency of the crest the spillway is adequate to take care of all river flow, as a slight raise in pool level will compensate for the small loss in effectiveness of the spillway.

11-05. STABILITY DIAGRAMS. - This report includes complete computations for the stability of all sections of the dam for the two critical loading conditions and for both the two-thirds uplift and alternatively for the full tailwater plus 50 percent of headwater and tailwater differential conditions. Plate Nos. XI-6, XI-7, XI-8, XI-9, and XI-10 show loads and stresses at various elevations for the full tailwater plus 50 percent differential uplift for all typical sections of the dam. Sketches XI-1, XI-2, XI-3, XI-4, and XI-5 show the same data for the two-thirds uplift condition. It will be noted that while the dam is stable for either condition of uplift the two-thirds uplift is somewhat the more severe condition. As all stresses

are low this fact is of importance only in determining the amount and position of steel reinforcement within the pier at the 20-foot pier monoliths (XI-6 and XI-1). It will also be noted that the spillway ogee will require reinforcement above elevation 195 if two-thirds uplift is assumed. These stability diagrams are self-explanatory and they make clear the fact that all stresses are low in intensity for a gravity dam on a sound rock foundation. The buttressing effect of the downstream rock face has not been taken into account, but it would undoubtedly add to the factor of safety against sliding. This factor of safety based on shear-friction alone is estimated to lie between 10 and 20, varying with the character of the rock.

ANALYSIS OF DESIGN FOR LONG SAULT DAM

SECTION XII

INVESTIGATIONS OF OVERBURDEN AND BEDROCK FOR FOUNDATIONS AND EXCAVATIONS AND MATERIALS FOR EMBANKMENTS, COFFERDAMS, AND CONCRETE AGGREGATES

12-01. FIELD EXPLORATION OF OVERBURDEN AND BEDROCK PRIOR TO OCTOBER 1940.- Prior to October 1940, the Governments of Canada and the United States and various private companies made investigations in the vicinity of the Long Sault Dam site for the purpose of determining the overburden and rock conditions. Most of the field exploration was of a preliminary nature for the purpose of studying various plans and layouts of the project as a whole. The most detailed explorations were made in 1925-1926 by the Joint Board of Engineers on St. Lawrence Waterways Project at a site upstream a few thousand feet from the present proposed location of the dam. The exploration consisted of drilling holes through the overburden by wash boring method and into the bedrock with core bits and the sinking of two shafts into bedrock, one on Barnhart Island and one on Long Sault Island, from which horizontal drilling toward the channel was conducted. Some of the field logs of the drilling done in the vicinity of the site prior to October 1940 are on file in the district office. The location of all drilling prior to October 1940 is shown on Plate XII-1.

12-02. FIELD EXPLORATION OF OVERBURDEN AND BEDROCK SINCE OCTOBER 1940.

(a) General. - Overburden and bedrock exploration at the dam, wing dams, dike, cofferdams and Cuts "C", "F", AND "G" since October 1940, conducted by the U. S. Corps of Engineers for the purpose of obtaining information for designs included extensive geological reconnaissance, drilling in overburden and rock, excavation and sampling of test pits, test trenches and auger holes, and the determination of bedrock elevations by the seismic method. The location and extent of the exploration at the sites are shown on Plate XII-1. Sheet BD-1-1/5 of the contract drawings shows the location of all exploration except seismic. Complete reports of the drill holes, test pits, and test trenches, and the notes and computations of the seismic investigations are on file in the district office. Records of the drilling exploration are shown on sheets BD-1-1/6, 1/7 and 1/8 of the contract drawings. All soil samples and rock cores are stored in the district soils laboratory.

(b) Drill Holes. - Holes were drilled in the overburden and rock with diamond core drilling equipment using 3½-inch casing in overburden and 2-1/8-inch bit to obtain bedrock cores. The overburden was dry sampled using a 2-inch sampling tube. Eighteen of the holes were entirely wash bored through the overburden, and no soil samples were obtained. In the other 22 holes drilled, dry sampling to obtain soil samples was attempted at approximately 6-foot intervals or at changes in material, and wash boring between samples was permitted. A total of 40 holes was drilled at the sites with a total footage of 1.436 feet in overburden and 1.915 feet in rock.

(c) Test Pits. - Test pits, test trenches, and auger holes were excavated and sampled to determine the characteristics of the overburden in the abutments and of foundations for the wing dams and dike. The test pits were excavated to a depth of approximately 6 feet, and whenever possible, auger boring was extended below this depth. In general, bag and jar samples and photographs were taken. A total of 36 test pits and 6 test trenches was excavated and sampled. Besides test pitting and trenching, 12 holes were augered in two foundation areas of the dike.

(d) Seismic Investigations.

(1) Seismic investigations were conducted in the vicinity of the dam and the cuts to determine the location of bedrock prior to drilling and supplement the drill hole information. The work was done under the direction of A. E. Wood, Associate Geologist of the Binghamton District and E. R. Shepard, Senior Physicist, Office of the Chief of Engineers. The method developed by Mr. Shepard was used for investigation on land (for brief description, see article "The Seismic Method of Exploration Applied to Construction Projects" by E. R. Shepard, the Military Engineer, September-October, 1939). Special subaqueous exploration by seismic methods was conducted at the dam site in the river channel and in swift water where drilling would be expensive. Mr. Shepard adapted the conventional seismic methods used on land to the requirements of sub-aqueous conditions by developing special apparatus and technique. The determinations in the slow or moderately swift water were obtained from a line laid out like normal lines on the land. The detectors were placed in a cartridge and held on the channel bottom with special equipment. Observers on shore located the position of the line. In the rapids where it was impossible to satisfactorily maneuver boats or place detectors, a different technique was devised. A single detector and the receiving apparatus were placed on the shore or on the bar in the river (near drill hole D-1364) close to the region to be explored and at a point where the depth and velocity of wave propagation of the overburden was already known from drilling records or seismic tests. The explosive charge was carried into the rapids either by boat or by use of a float. The location of the position at which the charge was dropped was determined by two observers with transits on the shore.

(2) A total of 16 lines were fired on land at the dam site and at Cuts "C" and "G". Twelve determinations were made at locations in the river channel. Twenty-three lines were fired in the vicinity of Cut "F". The results of the lines shot on land are considered within the usual accuracy obtained by seismic methods since no difficulties were encountered. The results of some lines fired were inaccurate due to frost conditions, and therefore, the positions are not shown on Plate XII-I. The results of the line shot in water (S414) are considered generally comparable in accuracy to the land determinations. The results of the seismic work in swift water where single shots (SS415 to SS418 and SS3674 to SS3680) were fired are considered approximate due to the difficulty in obtaining the position of the charge, lack of accurate sounding data and the assumption that the overburden is uniform. The exact position of the charge was difficult to determine due to the water transporting the charge. An error of 3.4 feet in the measurement of the shooting distance with a velocity ratio of 17000/5000 results in a 1-foot error in the depth to rock. To compute the elevation of the rock surface, it was necessary to use sounding data from previous surveys. A complete detailed report of the seismic investigations conducted for the St. Lawrence River Project will be placed on file in the district office.

12-03. EXPLORATION OF MATERIALS FOR THE EMBANKMENTS, COFFERDAMS, AND CONCRETE AGGREGATES.

(a) Earth and Rock Fill. - The exploration described in paragraph 12-02 for the overburden and bedrock served in part to locate suitable earth and rock fill materials for the wind dams, dike, cofferdams and for the treatment of the abutments. The overburden exploration was supplemented by the excavation and sampling of 13 test pits in a manner as described in paragraph

12-02 (c). Since suitable earth fill material is available in the vicinity of the wing dams, dike, and from the excavation of cuts, and suitable rock is available from the required excavation, an extensive program of exploration was not required. The borrow areas for the embankments are shown on Plate XII-I which contain suitable materials were located due to their respective positions to the structures. These areas are considerably larger than required, and it is planned to make further explorations within each area to determine which sections contain the most suitable materials. Rock is also available from out cropping deposits in the north channel on the north side of Barnhart Island. No exploration was conducted at this location because surface indications show that it is of the same formation as the rock at the dam site.

(b) Sand and Gravel Filter and Backing. - Exploration was conducted to locate deposits of suitable material for the sand and gravel filters and backing of the embankments. It is believed that all deposits within a radius of 15 miles of the site have been located. The most feasible deposits were sampled and tested to determine the gradation of the material. A complete report of these investigations will be placed on file in the district office.

(c) Concrete Aggregates. - Exploration to locate suitable sources of concrete aggregates are being conducted. It is planned that the explorations will be completed so that information will be available prior to letting of the contract. Many deposits of sand andgravel within a radius of 25 miles of the site have been sampled and representative samples have been tested in the Central Concrete Laboratory, West Point, New York, to determine the suitability of the materials for concrete aggregates. The most promising rock quarries in the vicinity have been sampled and the materials tested in the Central Concrete Laboratory. The bedrock exposed along the north shore of Barnhart Island and that which will be excavated at the dam site is not considered suitable for concrete aggregate. Studies are being made to determine if suitable stone sand can be produced from rock available from local quarries for fine concrete aggregate. Natural deposits of sand or sand and gravel are being explored which are outside of a 25-mile radius and are near a railroad or near the St. Lawrence River. Complete report of all investigations will be placed on file at the district office.

12-04. LABORATORY TESTS ON SOILS.

(a) Soil Tests. - Due to the type of overburden materials in the foundations and excavation areas, materials available for embankment construction, and the size of the earth embankments, an extensive program of soil testing was not made. All soil samples were classified using the M. I. T. scale of classification and recorded in a final report of each hole. The grain size distributions of a sufficient number of samples were determined by the usual sieve and hydrometer methods to serve as a guide in the classification of all samples. General geological descriptions of the overburden at each drill hole were prepared after studying the laboratory classifications and the field logs shown on Plate XII-2. Moisture contents were determined on 50 samples of till and clay taken from drill holes in the vicinity of the sites. No moisture content determinations were deemed necessary for the other materials since the natural moisture contents vary appreciably with climatic conditions. No specific gravity, natural density determinations, shear or permeability tests were made.

12-05. FIELD AND LABORATORY TESTS ON ROCK.

(a) General. - To determine the quality and character of the bedrock, field tests were conducted at some of the drill holes. Cores obtained were classified in detail by visual inspection, and laboratory tests were performed on selected samples. The laboratory testing program was made in conjunction with the program for the powerhouse. The proposed powerhouse site is located at the downstream end of Barnhard Island approximately 4 miles downstream from the Long Sault Dam site. The bedrock at each site is of the same origin and composition and, therefore, samples for laboratory tests were selected regardless of the site to obtain the most suitable specimens for test and the most representative of the various beds in the rock formations. The test results on samples from one site are considered valid for both sites.

(b) Pressure Tests. - During the current field investigations, pressure tests, using standard pressure pumping equipment, were conducted in the bedrock in the vicinity of the site at 11 of the 13 drill holes which extended 40 or more feet into the rock. At drill holes D-1002 and D-1004 which were drilled 100 feet into rock, no pressure tests were conducted. The data of the tests are recorded in the report of each hole on file in the district office and the results are shown graphically on Plate XII-3. Difficulties were encountered during most of the tests due to extremely cold weather. Leakage in these tests was apparently confined to seepage along natural bedding planes and joint cracks in the rock.

(c) Classification. - The rock cores obtained from drill holes were classified by a geologist. The condition of the bedrock was determined by an interpretation of the field logs and pressure test data and visual examination of the cores. Detailed and general classifications are recorded in the final report of each drill hole. The general classifications are shown on sheets BD-1-1/6, 1/7, and 1/8 of the contract drawings.

(d) Shear Tests.

(1) Tests were made in the Binghamton District laboratory on core drill samples to determine the shearing strength of the various rocks which occur in the foundation. Three types of shear tests were performed, namely direct shear for breaking and sliding, double shear with and without axial loading and compression tests. Testing in the direct shear machines was limited to shale specimens. In the testing procedure each sample was firmly set in plaster of paris in the upper and lower housings of the shear box and tested in shear at various normal loads. It was possible to break several specimens of one class of shale and thus determine the cohesion, but in most instances, the specimens were intentionally fractured along a bedding plane prior to testing so that actually a sliding test was conducted. All tests were run submerged. In perparing specimens for the compression test, a 2 to 1 ratio of length to diameter was adopted. The ends were capped with "Hydrolite" and then faced off in a lathe. The rate of loading in the Universal testing machine was approximately 2,000 lbs. per minute. A description of the double direct shear tests is omitted since the accessory equipment did not function satisfactorily and the results are not considered valid.

(2) The results of the compressive strength tests are as follows:

Material	Site	Hole	Elevation	Compressive Strength p. s. i.
Shale	Long Sault Dam	D-1016	124.0	7900
Shale	Long Sault Dam	D-1016	96.8	6950
Dolomite	Long Sault Dam	D-1057	148.7	7100
Dolomite	Powerhouse	D-1037	95.2	9300
Limestone	Long Sault Dam	D-1016	136.0	5750

Material	Site	Hole	Elevation	Compressive Strength p. s. i.
Limestone	Long Sault Dam	D-1016	136.0	7450
Limestone	Powerhouse	D-1024	111.7	4950
Sandstone	Powerhouse	D-1026	84.1	13200

The results are somewhat erratic, due in several instances to the variation in structure and composition of the specimens and the fact that irregularities in the relatively small specimens (2-1/8 inches in diameter) influenced the type of failure. Fracturing of the samples was in general quite irregular, occurring in vertical cracks and inclined at varying angels to the axis and occasionally along joint planes. However, the direct shear tests on shale indicated fairly consistent results. From one set of specimens, obtained at elevation 126 from Drill Hole D-1016, a friction angle of 23.5 degrees was indicated with a cohesion of 0.8 tons per square foot. It was possible to break only one shale specimen of another set obtained at elevation 98 from drill hole D-1016, in the direct shear machine, which indicated a high cohesion value. The material of this set also had a high value of maximum sliding shear due to interlocking on the sliding plane and an ultimate sliding shear friction angle of 31 degrees.

(e) Freezing and Thawing Tests.- Specimens of shale, dolomite, limestone and sandstone were taken from the following holes and subjected to 9 cycles of freezing and thawing:

Material	Site	Hole	Depth	Elevation
Sandstone	Powerhouse	D-1026	81.2-81.5	80.8
Shale	New Cornwall Canal	D-1122	43.3-43.6	153.0
Dolomite	Powerhouse	D-1026	60.4-60.7	102.1
Limestone	Powerhouse	D-1028	51.9-52.1	109.1

The tests were conducted during the winter. A cycle consisted of freezing the specimen in water outdoors for a period of sixteen hours followed by thawing at a temperature of approximately 22 degrees Centigrade for a period of 8 hours. The condition of the specimens before testing and after nine cycles are shown by the photographs on Plate XII-4. The dolomite, limestone, and sandstone showed little or no effect from the tests. The shale, however, broke into numerous thin discs, wafers and small flakes. These breaks all occurred along bedding planes in the shale, and there was no tendency of the rock to break down to its original silt and clay. The tests were discontinued only when weather conditions did not allow freezing outdoors at night.

(f) Slaking Tests.

(1) Specimens of shale, dolomite, limestone, and sandstone taken from the following locations were used for initial slaking tests:

Test	Material	Site	Hole	Depth	Elevation
Oven dry	Sandstone	Powerhouse	D-1026	79.2-79.5	82.8
Oven dry	Shale	Powerhouse	D-1028	56.6-56.9	104.4
Oven dry	Dolomite	Powerhouse	D-1026	95.5-95.8	166.5
Oven dry	Limestone	Powerhouse	D-1027	38.0-38.2	152.9
Air dry	Sandstone	Powerhouse	D-1026	79.0-79.2	83.0
Air dry	Shale	Powerhouse	D-1028	56.2-56.4	104.8
Air dry	Dolomite	Powerhouse	D-1026	91.7-91.9	70.3
Air dry	Limestone	Powerhouse	D-1027	30.2-30.4	130.7

Each specimen was subjected to eleven cycles of wetting and drying. A cycle consisted of soaking the specimen in distilled water for a period of three days followed by drying the specimen for a period of four days. One set of specimens was air dried at approximately 22 degrees Centigrade, while the other set of specimens was oven dried at approximately 105 degrees Centigrade. The condition of the specimens prior to testing and after 2 and eleven cycles are shown on Plates XII-5 to XII-7, inclusive.

(2) During the initial tests, the shale broke down into numerous wafers. Therefore, a second series of tests was started using specimens of shale taken from the following locations to determine if various beds of shale had the same characteristics.

Test	Site	Hole	Depth	Elevation
Oven dry	Long Sault Dam	D-1019	38.4-38.6	134.1
Oven dry	Long Sault Dam	D-1016	85.4-85.6	88.3
Air dry	Long Sault Dam	D-1019	36.6-38.7	135.9
Air dry	Long Sault Dam	D-1016	85.6-85.8	88.1

The condition of specimens prior to testing and after 2, 11, and 15 cycles are shown by the photographs on Plates XII-8 and XII-9, inclusive.

(3) During the tests, the dolomite, limestone, and sandstone were not greatly affected. The shale, however, as in freezing and thawing tests, broke down into numerous wafers and flakes. There was no tendency to break down to its original silt and clay. In the same number of cycles, the shale subjected to oven drying broke down more than that subjected to air drying. The second series of tests indicated that the shales from the several beds selected apparently broke down at about the same rate and to the same extent.

(g) Solubility Test on Dolomite, Limestone and Sandstone.

(1) Solubility tests were conducted to determine the solubility of dolomite, limestone, and sandstone. No tests were performed on samples of shale since it was evident from slaking tests that valid measurements could not be made. The samples which are considered representative were chosen from these tests and were taken from the following locations:

Material	Site	Hole	Depth	Elevation
Sandstone	Long Sault Dam	D-1060	53.0	154.6
Dolomite	Long Sault Dam	D-1004	87.0	93.0
Limestone	Long Sault Dam	D-1006	40.0	133.4

The procedure consisted of immersing each sample in St. Lawrence River water for a period of 6 days and on each 7th day the sample was oven dried at a temperature of 110 degrees Centigrade for a period of 16 hours, cooled in a desiccator and weighed. The 3 samples were immersed in 1 storage jar containing 700 c.c. of water which was changed daily. Preliminary test were made to establish the procedure for drying. It was found that consistent results could not be obtained by drying the sample in air and that when the sample was dried in the oven for more than 16 hours, the weight did not change.

(2) The samples had the following apparent specific gravity, initial weights and surface areas prior to the starting of the final tests:

	Limestone	Dolomite	Sandstone
Initial dry weight in grams	569.13	547.48	425.58
Approximate surface area in sq. cm.	201.6	192.0	162.0
Apparent specific gravity	2.7	2.8	2.7

The results obtained are as follows:

Weighing No.	Grams dissolved per 6 day period Limestone	Dolomite	Sandstone
1	.11	.17	.06
2	.10	.03	.02
3	.00	.01	.00
4	.10	.15	.03
5	.20	.18	.06
6	.03	.11	.01
7	.14	.13	.09
8	.13	.12	.01
9	.12	.13	.10
10	.29	.01	.02
11	.08	.02	.03
12	.13	.15	.07
13	.08	.11	.01
14	.09	.06	.01
Total grams dissolved in 84 days	1.60	1.32	0.46
Average grams dissolved per 6 day period	0.114	0.094	0.033

The above tabulation shows that the quantity disolved during each 6 day period was not constant or uniformly varying. The large variation in some cases was due to the formation of fresh cracks as determined by study of the photographs and notes. Plate XII-10 is a photograph showing the initial and final conditions of the samples.

(3) The procedure used in the tests did not produce the conditions which exist in nature and therefore the results of the tests must not be considered as valid for natural conditions. The main variation from the natural conditions were (1) the water was not under pressure, (2) the samples were oven dried after each 6 days of immersion, and (3) the water was obtained from the river surface. However, the results indicate that if St. Lawrence River water flows very slowly over fresh surfaces of limestone, dolomite, and sandstone, in a period of 3 months, approximately 7.4, 6.4, and 2.6 grams respectively will dissolve from each square foot of surface. It is believed that these results are sufficiently accurate for the problem involved and more refined tests are not required. The depths to which the three types of bedrock will dissolve in the same period cannot be determined since it is believed that part of the constituents of each type dissolves faster than others. However, assuming that all constituents do dissolve at the same rate, the corresponding dissolved depths in the first 3 months for the limestone, dolomite and sandstone would be approximately .0012, .0010, and .0004 inches, respectively.

(h) Solubility Tests on Gypsum. - No solubility tests were made on specimens of gypsum from the bedrock at the dam site. Test have been made on specimens obtained from the powerhouse foundation which show that the gypsum is very soluble. These tests are described in detail in a report describing the investigations at the powerhouse site on file in this district office. The only gypsum encountered during the drilling at the dam site was a 4 foot bed at elevation -15 which is approximately 165 feet below the general bedrock

surface. If gypsum occurs at higher elevations as may be determined by future exploration, the gypsum, as indicated by the tests for the powerhouse investigations, may be considered very soluble and the proper treatment must be undertaken to produce a satisfactory foundation.

12-06. RECOMMENDED FUTURE INVESTIGATIONS. -

(a) General. - Additional investigations should be conducted prior to and during construction to determine the overburden and rock conditions at the sites of the dam and upper cofferdams, and to locate the most suitable materials within the borrow areas. Drilling should be conducted to a depth required to locate the position of the 4 foot gypsum bed under the dam and to determine if any gypsum occurs at the upper zones. Drilling should be conducted in the channel at the upper cofferdam to determine the overburden conditions and in the east side of the channel at the dam site to determine the elevation of bedrock. Test pits should be excavated within the proposed borrow areas to determine the variation of the soil condition and to locate the material most suitable for embankment and cofferdam construction.

DESIGN ANALYSIS: LONG SAULT DAM

SECTION XIII
DESIGN OF WING DAMS, DIKE AND FOUNDATION FOR THE DAM

13-01. GENERAL. - The design of the wind dam, dike and dam foundation involved a study of the foundation conditions and characteristics, a study of the characteristics of the available embankment materials, the choice of a section which will utilize economically the available embankment materials and will be safe under any conditions. The methods and the extent of the investigations to determine the characteristics of the foundation and embankment materials have been described in Section XII. This section includes a description of the results of those investigations which are pertinent to the design and a discussion of the choice, economy, and design of the wind dams and dike and a discussion of the foundation treatment for the dam.

13-02. GEOLOGICAL FEATURES AND CHARACTERISTICS OF FOUNDATION MATERIALS.

(a) Description of Site. - The dam site is located across the south channel of the St. Lawrence River and extends from the New York State Mainland to Barnhart Island near the downstream end of Long Sault Island and the foot of the Long Sault Rapids. No bedrock outcrops occur at the site and the river is entirely controlled by glacial drift. Although little data is available, soundings indicate that a bedrock valley exists under the north end of the proposed dam. This valley is partially filled with glacial till. A boulder pavement is believed to occur on the bed of the river. Hills composed almost entirely of glacial till rise above the river to form both abutements. The earth wing dams and dike extend from the dam on these till hills.

(b) Bedrock.

(1) The bedrock at the site, as shown by cores recovered from drilling, is dolomite interbedded with thin strata of limestone, sandstone and shale. The general rock classifications at each drill hole are shown on sheets (File Nos. ED-1-1/6, 1/7 and 1/8) of the contract drawings. More detailed classifications are given in the reports for each drill hole on file in the district office. The strata of limestone and sandstone vary in thickness from 2 inches to 10 feet. The shale beds are from 2 inches to 6 feet thick. Near the right abutment there is one shale bed at about elevation 130, which is approximately 6 feet thick, but most of the shale beds are less than 6" thick. One bed of gypsum, approximately 4 feet thick, was found in drill hole D-1059 at elevation -15, corresponding to a depth of 165' below the general bedrock surface. This was the only occurance of gypsum found in the vicinity of the site. However, gypsum may occur at higher elevations as thin films and veins in joints, bedding planes and fractures, as local disseminated deposits in the dolomite and in very thin beds similar to the occurrence at the powerhouse site which is located on the same bedrock formation. A similar and apparently the same 4 foot bed of gypsum encountered at the Long Sault Dam also occurs at the powerhouse site located 4 miles downstream at elevation -15, which indicates that this bed may be persistent throughout the region.

(2) The upper strata at the site were deposited as part of the Chazy formation as determined by characteristic fossils found in the rock cores and in the outcrops along the north shore of Barnhart Island. In the rock core obtained at elevation 96 in drill hole D-1059, there is a disconformity which indicates an erosion interval and, therefore, the lowest strata at the site are of a different age than the upper strata. The lower strata may be part of

the lower Chazy or the Beekmantown formations, which are both lower Ordovician in age. A similar and in fact apparently the same disconformity was found at elevation 113.9 in drill hole D-1131 at the powerhouse site which is known to be fairly close to the contact between the Chazy and the Beekmantown formations. The Beekmantown formation is known to occur at the bedrock surface 4 miles south and 4 miles east of the dam site. The 4-foot bed of gypsum is believed to have been deposited in a shallow salt lake in a region of semi-arid climate.

(3) Bedrock contours drawn from the information obtained from drilling and seismic investigations are shown on Plate XII-1. No information is available as regards the depth to rock in the center of the main channel at the dam site. Soundings of the channel bottom below the site, however, appear to indicate a rock draw and the bedrock contours have been drawn to show this condition. The contours have been extended beyond areas of extensive exploration to show the general trend of the rock surface. The bedrock contours in the immediate vicinity of the cuts and structure foundations where exploratory data is available are considered sufficiently accurate for design purposes. The validity of the contours outside these areas may be evaluated from the intensity of the exploration. The present configuration of the rock surface is the result of preglacial erosion.

(4) The rock is generally sound, hard and unweathered. The bedding is nearly horizontal as determined by examination of the rock cores and outcrops on the north side of Barnhart Island. The bedrock is intersected by several joint systems, apparently haphazard in pattern. A study of the drill hole field logs, visual examination of the rock cores, and the result of pressure pumping tests show that no large cavities or open fissures exist in the rock in the areas where exploratory data is available. The condition of the bedrock in the stream channel is not known, but it is believed to be the same as near the abutments if no fault zones exist.

(5) The limestone, dolomite, and sandstone in the foundation are structurally sound, but slightly soluble, as determined by the tests described in paragraph 12-05(g). The shale which occurs is hard and will not break down to its original silt or clay when subjected to weathering agencies. However, the shale will break into thin, flat fragments. The shearing strengths of rock in the foundation are indicated by the results given in paragraph 12-05 (d). The gypsum is very soluble as determined by tests for the powerhouse investigations.

(c) Overburden. - The overburden on both abutments, in the river channel and in the dike foundation area is glacial till except for the superficial deposits of boulders, marine clay and beach material which occurs on the surface in some areas. The glacial till is compact, relatively impervious and unstratified. No lenses or beds of pervious material occur in the till. The classification of the overburden at each drill hole is shown on sheets (File Nos. BD-1-1/6, 1/7, and 1/8) of the contract drawings. The overburden in the south abutment is a very compact, clayey sand and gravel with scattered cobbles and boulders. It is estimated that the coefficient of permeability is 0.00000001 cm. per second. The overburden in the river channel is believed to be compact clay, sand and gravel overlain by a payement of boulders, cobbles and gravel. The overburden in the north abutment and in the foundation for the dike is a compact silty sand and gravel with scattered cobbles and boulders except in a few limited areas of the dike foundation where shallow, superficial deposits of clay and sand gravel occur. The estimated coefficient of permeability of the compact silty sand and gravel is 0.00001 cm. per sec. It is

estimated that the overburden in the left abutment and in the foundation for the dike has a cohesion of 0.1 tons per square foot and an angle of internal friction of 40°. The overburden in the right abutment has a cohesion of 0.3 tons per square foot and an angle of internal friction of 30°. Using the results of the water content determinations shown on Plate XII-2, it has been computed that the unit dry weight of the glacial till is approximately 130 pounds per cubic foot corresponding to a saturated weight of 143 pounds per cubic foot. In the foundation of the dike between the two knolls which are glacial till is a shallow deposit of marine clay, approximately 10 feet in depth. For a distance of 100 feet near the eastern end of the dike, the overburden to a depth of 5 to 10 feet is a loose sand and gravel and numerous cobbles and boulders. This superficial deposit is a characteristic beach deposit. Typical grain size curves of the foundation materials are shown on Plate XIII-1.

13-03. AVAILABILITY AND CHARACTERISTICS OF EMBANKMENT MATERIALS.

(a) General. - The materials for the embankments will be obtained from structure excavation, from the borrow areas shown on Plate XII-1 and from gravel deposits selected by the contractor. The borrow areas for the earth fill section contain the most economical materials in the vicinity which are suitable for a safe design. The following paragraphs describe the characteristics of the deposits and materials to be utilized, as determined by the investigations described in Section XII which influence the design of the dike, wing dam, and abutment embankments.

(b) Earth Fill. - The materials for the earth fill sections of the wing dams and abutments and for backfill will be obtained from the structure excavation, and if necessary, from the borrow areas. The material will have the characteristics described in paragraph 13-02(c) for glacial till. The materials for the dike will be obtained from the borrow areas on Barnhart Islands. Prior to construction, these areas will be explored to determine the location of the most suitable materials. The quantity of material within these areas shown is in excess of that required to permit a selection. The material within these areas is a compact silty sand and gravel with scattered boulders and numerous cobbles. It is very well graded and it is estimated that when compacted it will have coefficient of permeability of 0.00001 cm. per sec. Typical grain size curves of the material within the borrow areas are shown on Plate XIII-2.

(c) Sand and Gravel. - Sand and gravel for the downstream filter blanket of the dike and wing dams and for the backing under the riprap will be obtained from sandy gravel deposits as selected by the contractor. There are within 15 miles of the site small superficial deposits of sand and gravel containing material which is believed to be suitable.

(d) Riprap. - Material rock toe fillet of the dike and wing dams and for riprap will be obtained from structure excavation and from embankment materials. The rock obtained from structure excavation will be composed mainly of sound dolomite and limestone.

13-04. TREATMENT OF DAM FOUNDATION. - The foundation for the dam, bulkheads and training walls will be sound bedrock. All loose, weathered or badly fractured rock will be excavated to produce a suitable foundation. The bedrock will be thoroughly grouted as shown on the contract drawings. Shale beds will be excavated to found the base of the structures on beds of other rocks. If gypsum is located at higher elevation than the 4 foot bed, the foundation will be grouted to greater depths than shown on the drawings.

13-05. WING DAM AND DIKE SECTIONS. - As the design progressed to its final stage the sections shown on Sheets BD-1-20/1 and BD-1-20/2 of the contract drawings were developed. Initial sections were the same as those shown except for details of the riprap blankets and a downstream rock toe and blanket was considered instead of the sand and gravel filter blanket. The top width of the sections was governed by the width necessary for highway and railroad. The clay in the dike foundation area will be removed to insure a stable foundation. The essential features of the dike and wing dam embankments will be as described in the following paragraphs.

(a) Impervious Features. - The wing dam and dike will contain earth fill sections of material having a small coefficient of permeability. The central section of the earth fill will be heavily compacted with a sheepsfoot roller and therefore will be slightly more impervious than the outer sections. The compacted earth fill will extend a few feet into the foundation overburden to provide a cut-off in the upper overburden materials and in the beach materials. Compacted earth fill will encase a part of the bulkheads.

(b) Drainage Features. - To control the seepage through the embankments and foundation, a filter blanket is provided under the downstream section. It is believed that the filter will prevent any seepage from exuding on the downstream slop. A small rock fillet is provided at the downstream toe to insure against erosion.

(c) Slope Protection. - The slopes of the embankments will be protected against erosion by heavy riprap underlain with small rocks and sandy gravel. The downstream slope above the rock fillet will be protected with seeded areas.

13-06. BACKFILL AND ABUTMENT TREATMENT. - Backfill around the bulkheads will be compacted earth fill. The material will be obtained from structure excavation. The abutments will be excavated to the slopes shown on the contract drawings. The slopes will be protected with riprap. The riprap on the slope downstream from the bulkheads will insure against sloughing which might be produced by ground water or rain wash. The riprap upstream from the bulkheads will insure against erosion due to any currents which might develop.

13-07. ANALYSIS OF EMBANKMENT SECTION. - No mathematical analyses have been made of the embankment sections. Such analyses are believed to be unnecessary. Based on experience with similar materials and sections, it is believed that the sections have ample safety for stability and that the quantity of seepage will be very small. Sufficient free board has been provided to compensate for any settlement which might occur.

13-08. ECONOMY OF CONSTRUCTION. - The embankments will be composed of suitable earth and rock materials from the structure excavations and from nearby borrow areas. Provisions have been made to utilize all of the stone and boulders from the earth fill material. A sand and gravel filter blanket has been provided under the downstream section in place of a downstream shell so that a minimum quantity of sand and gravel will be used. It will be necessary to transport sand and gravel to the site. A downstream rock blanket and rock toe were not incorporated in place of the sand and gravel filter in order to save rock for other structures on the project and to simplify construction.

DESIGN ANALYSIS: LONG SAULT DAM

SECTION XIV - COFFERDAMS AND DIVERSION

14-01. HYDROLOGY. - The St. Lawrence River has its source in the Great Lakes system. By far the greater portion of the runoff from the tributary area above the Long Sault Dam passes through the lakes, which regulate the flow to such extent that the river is not subject to floods. For this reason the design of the hydraulic features of the dam can be predicated wholly on records of past flows (Plate XIV-1) and no further hydrological studies or studies of maximum floods have been made. A memorandum summarizing data received from the Canadian Authorities, and believed to be of general interest, is attached hereto as Exhibit XIV-1.

14-02. COFFERDAMS AND DIVERSION - DESCRIPTION.

(a) General. - The Long Sault Dam is to be located across the main channel of the St. Lawrence River immediately downstream from the Long Sault Island and a short distance below the foot of the Long Sault Rapids. It is proposed that the dam be constructed in two sections; the first to include the south abutment and south portion of the dam and the second to include the north portion of the dam and the north abutment. The point of division between the two sections is placed opposite the end of Long Sault Island, which forms a natural division both for cofferdams and for diversion during construction. (See Plate XIV-2, Long Sault Dam Cofferdams - General Layout).

(b) Construction Schedule. - The construction of the dam in two sections, as above, will comprise three construction steps. The first step will be the construction of the south section; the second step will be the construction of the north section; and the third step will be the closure of openings left in the first and second step construction for passing the flow of the river prior to and during the closure. The construction period, as indicated on the attached preliminary construction schedule (Plate XIV-3) is estimated as approximately four years; the first step requiring about fifteen months; the second step about two years; and the third step from three to six months.

(c) Diversion. The discharge of the St. Lawrence River varies normally (about 92 percent of the years) from about 180,000 c.f.s. to 280,000 c.f.s.; the minimum and maximum for the 80-year period of record being 144,000 c.f.s. and 314,000 c.f.s. respectively (see Plate I). Of this discharge, from 20,000 to 27,000 c.f.s. is diverted by the Massena Power Canal and 2,300 c.f.s diverted at Lock 21 by Canadian authorities. The flow for any year is usually at a maximum in May or June and decreases steadily to a minimum the following January or February.

(d) During the first construction step the main flow of the river will be continued in the Long Sault Island Main Channel and the normal flow of the Long Sault Island South Channel will be diverted through cut "C". During the second step the flow will be diverted through cut "F" and the Long Sault Island South Channel and over diversion openings to be left in the first step construction. Diversion during the third, or closure, step will be through the diversion openings until these openings are closed off or raised to crest elevation, and the flow can be passed over the dam. Completion of the Barnhart Island powerhouse substructure to a stage such that a portion of the flow can be passed down the Barnhart Island North Channel and through the powerhouse during the closure of the Long Sault Dam will simplify the closure step, but is not required in the plans developed.

(e) During the construction period it will be necessary to maintain navigation throughout the reach affected and also to maintain proper water surface elevations at the intake of the Massena Power Canal. It will be necessary to reconstruct Lock 21 as a lift lock and to protect the lock and the Cornwall Canal to elevation 210. Other canals or locks upstream from the dam site will not be affected until the closure step, at which time the Farran's Point and Morrisburg Canals will be drowned out and navigation can proceed in the river channel. The proposed intake structure of the Massena Power Canal is scheduled for construction so that diversion into the canal after initiation of the second step of the Long Sault Dam will be through the new structure and the rising water surface will not interfere with the canal.

14-03. COFFERDAMS AND DIVERSION - FIRST STEP.

(a) First Step Construction. - That part of the dam to be constructed during the first step will be the south abutment and the spillway sections to and including pier 14. Forty-foot diversion openings will be left in spillway bays 1 to 13 inclusive for second step diversion. The remainder of the structure in this step will be completed to full height.

(b) First Step Cofferdams. - The location and designation of the cofferdams is shown on the general plan (Plate XIV-2). Cofferdam 'A', closing the Long Sault Island South Channel above the dam, will be an earth and rock embankment constructed to elevation 192. Cofferdam 'B', extending from the United States shore below the dam and around the end of the south section of the dam to connect to the Long Sault Island, will be a timber crib structure constructed to elevation 188; except that a portion of that part of cofferdam 'B' which is upstream of the dam axis will also be used as part of the second step cofferdams and will be raised to elevation 205 for the second step.

(c) Cofferdam 'A' was located immediately below diversion cut 'C' and at the head of diversion cut 'G' to permit excavation of the greater part of the latter in the dry. Due to the necessity of maintaining the status quo of the water levels at the intake of the Massena Power Canal and of maintaining a channel to sluice floating ice away from this intake, it was not considered practical to locate cofferdam 'A' near the head of Long Sault Island and thus take advantage of the smaller structure which would be necessary.

(d) First Step Diversion. - The main flow of the river will be continued in the Long Sault Island Main Channel and the flow of the Long Sault Island South Channel will be diverted through cut 'C'. During the construction of Cofferdam 'A', the Long Sault Island South Channel will be temporarily closed by raising the crest of the weir at the Massena Power Canal Intake; but immediately after completion of Cofferdam 'A', and in any event prior to the ice season, the weir must be restored to its original condition.

(e) First Step Hydraulics. - Except for the short period when the Massena Weir is closed, the first step construction will not affect Lock 21 or the Massena Power Canal. During the period when the weir is closed, it is estimated that the water levels at Lock 21 and the Massena Power Canal Intake will be raised between 0.5 feet and 1.0 feet, depending on the flow. Estimated water surface profiles down the Long Sault Island South Channel and through cut 'C' are shown on Plate XIV-4.

(f) As it is necessary to close off the Barnhart Island North Channel for construction of the powerhouse, the flow normally passing down this channel must be carried by the Barnhart Island Main Channel, causing the water at the

dam site to rise about one foot over natural open water conditions.

(g) Ice gorges, which form downstream from the dam site during winter periods, may cause normal water surface elevations to be exceeded considerably; and it is necessary to determine the height of the downstream cofferdams to meet this condition. (See Table XIV-1). Since elevation 188 is exceeded only about one winter in five, this elevation has been chosen for the top of the downstream cofferdams.

TABLE XIV-1

Maximum Elevations at Trailrace of
St. Lawrence Powerhouse - Sheek Island

Year	Elevation	Year	Elevation
1913	182.2	1927	181.1
1914	187.2	1928	178.1
1915	179.9	1929	175.8
1916	179.0	1930	180.4
1917	188.1	1931	174.2
1918	196.2	1932	170.0
1919	170.0	1933	170.0
1920	187.2	1934	179.0
1921	170.0	1935	181.0
1922	177.5	1936	180.3
1923	180.0	1937	169.6
1924	179.7	1938	173.8
1925	183.2	1939	185.6
1926	176.1	1940	175.7

Information from Records of
St. Lawrence Power Co.

Times equalled or exceeded in 28 years

Elevation	Consecutive Periods of One year	Two years	Three years
196	1	2	3
195	1	2	3
194	1	2	3
193	1	2	3
192	1	2	3
191	1	2	3
190	1	2	3
189	1	2	3
188	2	3 1:5 yrs.	4
187	4	7	8
186	4	7	8
185	5	9	11
184 1:5 yrs.	5	9	11
183	7	11	14
182	8	11	14
181	10	16	19
180	13	20	25

14-04. COFFERDAMS AND DIVERSION - SECOND STEP.

(a) Second Step Construction. - The second step of the dam construction will comprise that portion of the dam from pier 14 to, and including, the north abutment. Several 40-foot diversion openings, as required for the closure plan to be adopted, will be left in this section and the remainder of the section completed to full height.

(b) Second Step Cofferdams. - The downstream cofferdam will consist of two sections; 'DU', from the upstream face of the dam to Long Sault Island and 'DD', from the downstream face of the dam to Barnhart Island. The cofferdam will be timber crib construction built to elevation 188 downstream from the dam and to elevation 205 upstream from the dam. As shown on general plan (Plate XIV-2) several cribs of first step cofferdam 'B' will be also used in cofferdams 'DU' and 'DD'. Timber crib bulkhead sections, built in the dry, will connect the completed section of the dam to the cofferdams.

(c) The upstream second step cofferdam 'E', will close the Long Sault Island Main Channel. The Long Sault Rapids, with a 30-foot fall in a relatively short distance, are immediately upstream from the dam site; and, in order to reduce the height of the cofferdam and the final closure head, cofferdam 'E' will be located a short distance above the head of the rapids. At this location the final closure head will be approximately 17 feet, i.e., the controlled water surface elevation at Lock 21 (elevation 199 minimum) minus the water surface elevation at the control above the Long Sault Rapids (elevation 182). The hazards of making the closure at this head make a stop-log closure advisable; and it is proposed to make Cofferdam 'E' a timber crib structure having fourteen 25-foot stop-log openings to be closed by concrete stop-logs after the final crib has been placed. Conditions at the placing of the last crib prior to closure by stop-logs are shown on Plate XIV-5. Since the Barnhard Island North Channel will be closed by the powerhouse cofferdam, it will not be necessary to place an additional cofferdam across this channel.

(d) Second Stop Diversion. - Diversion openings 40-feet wide are provided in each of spillway bays 1 to 13 of the first step construction for diversion during the second step. The sills of these openings are to be at approximately elevation 160, depending on the gates provided in the closure scheme finally adopted. The size and number of openings has been selected to pass the flow of the river with the water surface above the dam at about elevation 195; since computations of backwater have shown that a lower stage the hydraulic control shifts to upstream channel constrictions and that larger openings would be of no benefit.

(e) After the work to be done inside the first step cofferdams has been completed these cofferdams will be removed and the flow of the river will be diverted through cut 'F' and the Long Sault South Channel and over the diversion openings in the first step construction. The weir across the Long Sault Island South Channel at the intake of the Massena Power Canal will be removed to permit a greater flow down this channel. Cut 'G', which, except for a plug at the end of Cofferdam 'A', will have been excavated in the dry during the first step construction, is provided to increase the capacity of the lower section of the channel.

(f) Throughout the period of construction it will be necessary to maintain water surface elevations at Lock 21 and at the intake of the Massena Power Canal not lower than the normal water levels at these points. Dependable regulation at the diversion openings will be afforded by providing gates at the diversion openings in the dam. The gates will also be used to close the

the openings for concreting during the final closure.

(g) The removal of the weir at the Massena Power Canal Intake will increase the slope in the Long Sault Island South Channel from the head of Long Sault Island to the site of the weir and will result in approximately normal water levels at this point during the second step diversion. (Plate XIV-6, Table XIV-2) However, the construction schedule for the proposed intake structure provides for closing the present canal intake and diverting through the partially completed new structure when the second step diversion is initiated; and an increased water level will not interfere with the operation of the canal.

(h) Water Levels at Lock 21 will be raised during the second step diversion to approximately elevation 206.1, (Plate XIV-6, Table XIV-2) and it will be necessary to provide protection for the lock and canal. It is proposed to reconstruct Lock 21 as a lift lock and raise the Cornwall Canal dike prior to the second step diversion. Inasmuch as it will be desired to raise the water level at Lock 21 to about elevation 210 during the closure period and before the Cornwall Canal is abandoned, the lock and canal will be protected to elevation 210 which is ample for the second step diversion period.

(i) In the event that cut 'F' and the Long Sault Island South Channel were opened prior to closure of the Long Sault Island Main Channel, the resulting total channel area would be sufficient to lower water levels at Lock 21 below the permissible minimum (see Plate XIV-6). In order, therefore, to allow proper regulation during the transition from the first to the second step diversion a definite sequence of operations will be necessary as follows:

Hydraulic Summary
TABLE XIV-2

Discharge - Second Feet					Elevation - Feet				
Total	Massena	North Sault Channel	South Sault Channel Below Weir	Diversion Cut F	Above or at Dam	Massena Intake	Lock 21	Area Sq. Ft.	Est. Mean Velocity Ft./second
Existing Conditions:									
200,000	20,000	172,000	8,000	-	169.8	201.2	198.7		
			Between Long Sault & Barnhart Island at dam site					17,700	11.3
280,000	20,000	237,000	23,000	-	172.8	205.2	202.3		
			Between Long Sault & Barnhart Island at dam site					19,900	12.0
1st Step Construction:									
200,000	20,000	173,000	7,000	-	171.±	201.6	198.7		
			Between Point of Cofferdam & Barnhart Island					12,600	14.3
280,000	20,000	240,000	20,000	-	177±	205.5	202.3		
			Between Point of Cofferdam & Barnhart Island					16,200	16.1
2nd Step Construction:									
	With Massena Weir Out								
200,000	20,000	-	45,000	135,000	195.	200.9±	201.9±		
						In cut F		11,400	10.1
280,000	20,000	-	75,000	185,000	195	205.0	206.1±		
						In cut F		12,600	12.7

(1) Complete excavation of cut 'G', expecting a plug at the end of Cofferdam 'A', in the dry during the first step construction. Cut 'F', expecting a plug at the upper end, should also be completed during the first step.

(2) After completion of first step construction, remove cofferdams 'A' and 'B', including cut 'G' at the end of Cofferdam 'A', and raise Cofferdam 'DU' to elevation 205.

(3) Close off cut 'C' with earth plug to elevation 210.

(4) Close diversion gates and raise water in the Long Sault Island South Channel to elevation 200 to drown out the weir at the Massena Power Canal.

(5) Remove weir and remove plug in cut 'F'.

(6) Construct cofferdam 'E', increasing the flow down the Long Sault Island South Channel by opening regulation gates as the main channel is constricted and maintaining at all times a water level at Lock 21 not below elevation 199 or above elevation 208.

(j) Second Step Hydraulic Conditions - The 30-foot fall of the river through the Long Sault Rapids is more than is required for velocity head and friction slope through cut 'F' and the Long Sault Island South Channel; and the diversion has been designed to concentrate about two-thirds of the fall, or 20 feet, at the dam. It is contemplated that the water surface at the upstream side of the dam will be maintained by regulation to about elevation 195 (see water surface profiles, Plates XIV-7 and 8). However, any lowering of the water surface above the dam to the minimum required for discharge through the diversion openings (Plate XIV-9) would have little effect at Lock 21 or the intake of the Massena Power Canal as the hydraulic control would shift to upstream channel constrictions.

14-05. COFFERDAMS AND DIVERSION - CLOSURE STEP.

(a) General Closure Plans. - Two general plans for closure have been developed. The first, identified as Plan A, provides for raising the sills of the diversion openings step by step until all the flow is diverted over the completed spillway bays. The second, plan B, contemplates the diversion openings constructed as covered sluiceways, or conduits; final closure to be made by closing off these conduits with the diversion gates and raising the pool rapidly until the flow is diverted over the completed bays.

(b) Plan A. - Essentially, Plan A provides for raising the pool gradually to elevation 209 while maintaining uninterupted 14-foot navigation in the present canal system. Navigation is then to be suspended for the short period required to close the Cornwall Canal and raise the pool rapidly to elevation 225, at which point 14-foot navigation can be accomodated in the new Long Sault Canal. The pool may then be raised gradually until all the flow is diverted over the completed spillway bays. Inasmuch as the permanent spillway gates can be used for regulation and closure of the diversion openings by making them slightly stronger, the plan anticipates that these gates will be provided for use during the diversion and closure.

(c) The diversion openings proposed are to be open slots. The permanent spillway gates are to be used for regulation and for closure of the openings. Closure will be made by closing off groups of openings and pouring one or more lifts per closure, the flow of the river being passed through the remaining openings. It is anticipated that the Iroquois Dam will be used, within the limits dictated by the levels of Lake Ontario, to regulate the flow of the river to the capacity desired for diversion during the various closure moves; but, if the regulation thus available is inadequate, the schedule of closure may be varied to meet the conditions.

(d) In order to provide greater diversion capacity during the closure period and to permit a closure schedule conforming to a pool level requirements, it will be necessary to provide several diversion openings in the second stage construction in addition to the thirteen 40-foot openings left in the first stage construction. A closure schedule, which with the allowable regulation by Iroquois Dam is adequate for a year of normal river discharges, has been set up with five 40-foot openings in the second stage construction, making a total of 18 openings (Plates XIV-10, 11 & 12). If, at the time the final closure plan is definitely selected, it appears desirable to provide a greater number of diversion openings; gates for six openings, in addition to the eighteen proposed herein, can be made available; however the design of these extra gates would need to be revised to permit combinations of gate sections not at present considered. The diversion capacity at any time during closure can also be increased by varying the closure schedule; but the time required for closure would be greater.

(e) Inasmuch as it is proposed to use the permanent spillway gates for diversion regulation and closure, the elevation of the sills of the diversion openings (to a limited extent) and the raising of the pool at each move will depend on the heights of the gates available. A total of 42 gates are being provided for the spillway as follows:

Number	Type	Height
24	Single gates	25.67 feet high
6	Split gates	8.67 feet bottom and 17 feet top
6	Split gates	11.67 feet bottom and 14 feet top
6	Split gates	13.67 feet bottom and 12 feet top

The gates will be so designed that any top section can be combined with any bottom section or with any single gate section. Two bottom sections or a bottom section and a single gate section cannot be combined unless redesigned for this purpose. These gates may be combined for use in the diversion openings as follows:

Number	Sections Used	Total Height
6	25.67' - 17.00	42.67
6	25.67' - 14.00	39.67
6	25.67' - 12.00	37.67

and if additional openings are provided the six remaining single gates can be combined with six bottom sections (redesigned for such use) to make six gates 25.67 feet plus 13.67 feet or 39.34 feet high.

(f) At the beginning of the transition from the first to the second construction, the water level in the Long Sault Island South Channel will be held at about elevation 201, and it is necessary to place the sills of the thirteen diversion openings in the first step construction at such elevation that the top of the gates will be at elevation 201. Thus the sills in six openings (42.67-foot gates) are placed at elevation 160; six openings (39.67-foot gates) are placed at elevation 163; and one opening (37.67-foot gate) at elevation 165. During the closure period when the pool is raised to elevation 225, it will be necessary to close the openings left in the second step construction (37.67-foot gates) and the sills of these openings are placed at elevation 190.

(g) It is proposed to maintain 14-foot navigation in the present Cornwall Canal while the pool is gradually raised to elevation 209 and to this end it is proposed to redesign Lock 21 as a lift lock and to protect Lock 21 and the Cornwall Canal to elevation 210. Navigation above Lock 21 will not be affected while the pool is at elevation 209 or lower; but when the pool is raised to elevation 225 both the Farran's Point and Morrisburg Canals will be drowned out and navigation must be routed past these canals through the river channel. Velocities of flow in the Rapide Plat near the head of the Morrisburg Canal will be reduced by the higher stage until they are less than those normally encountered at the Goose Neck Island constriction (Plate XIV-13) and it is proposed to further reduce the Rapide Plat velocities by completing the proposed Ogden Island South Channel enlargement prior to raising the pool. Velocities past the Farran's Point Canal, with the pool raised to elevation 225, will not hinder navigation.

(h) The closure schedule developed for normal river flow is shown on Plate XIV-11. On the basis of beginning closure in July, this schedule is adequate, without regulation by Iroquois Dam, for six years of the 80-year record. With only minor regulation, i.e., temporary storage during several moves, of small volumes which could be released during other moves by increasing the normal flow by not more than 5 percent, the schedule is adequate for sixteen years of eighty; and by regulation limited only by the necessity of maintaining the level of Lake Ontario below the maximum predicated for operating conditions the schedule is adequate for all but ten years of eighty. Plate XIV-12 shows the conditions existing during a typical year requiring regulation. If closure were begun in August, the flows to be diverted are normally less and the degree of adequacy of the schedule somewhat greater. At any time, however, the schedule can be rearranged to provide diversion without regulation at Iroquois Dam by decreasing the number of openings to be closed at one time and increasing the time required for closure.

(i) Plan B. - Plan B contemplates that the diversion openings will be covered sluices or conduits. At the time of closure the regulation gates would be closed and the pool raised in one move until all the flow could be passed over the completed spillway bays. As soon as the sluices are closed, they can be concreted. Inasmuch as the pool, under this plan, will be raised in one move, navigation must be suspended during the period of raising the pool; but will not be otherwise interfered with. No openings other than those left in the first step construction for second step diversion will be required. Plate 14 shows the construction steps for this plan and Plate XIV-15 shows a diagram of the proposed regulation gates.

(j) It is desirable to have the diversion openings small to make the closure easier and reduce the size of gate required; yet, in order that ice may be passed without damaging or piling up behind the structure during the second stage diversion, the top of the opening should be at an elevation somewhat above the surface of the water flowing through the opening. The top of the diversion openings for plan B has been set at the elevation to which the water surface above the dam will normally be held (elevation 195), the drawdown as the flow enters the openings being sufficient to allow passage of ice. The sills of the openings have been set at elevation 160.

(k) When the openings are closed for final concreting, the pool will be raised until the flow can be passed over the completed spillway bays. It will be desirable to close off at least one bay adjacent to the work area; leaving 26 completed bays over which the flow can be passed. With a flow of 280,000 c.f.s., 20,000 c.f.s. of which will be diverted through the Massena Power Canal, the pool level would be raised to elevation 236.

(l) It is anticipated that the permanent spillway gates could be used for regulation and closure of the diversion openings in plan B. However, the head under which the final closure would be made (76 feet on the bottom and 41 feet on the top of the gates) would require that the gates be strengthened and made a great deal heavier than is necessary for their permanent functions.

(m) Discharge Through Powerhouse Channel. - Plate XIV-16 is attached hereto in order to show the approximate flow which could be diverted through the powerhouse substructure in the event that this channel was available during the closure step.

14-06. COFFERDAM DESIGN.

(a) General. - The general type of cofferdam proposed for Long Sault Dam consists of timber cribs, filled with quarry or acceptable rock from excavation, banked with an impervious fill, and connected to high ground by a shore fill. The water seal will be made by either a blanket of impervious material where no appreciable velocity is present or by a double steel sheet pile diaphragm sealed with concrete where high velocities will exist along the face of the crib. In order to reduce seepage under the cofferdams a toe trench, extending to rock or impervious material and backfilled with impervious fill, has been provided for all earth and rock embankments and all crib blanket fills adjacent to cribs not founded on rock.

(b) Cribs in continuous crib cofferdams have been laid out with a width equal to the height. To provide for extreme high water caused by ice jams at Lake St. Francis the cribs have been raised or "stepped" along their outside face, maintaining a maximum sliding coefficient of 0.45 assuming water load to top of crib and 5,000 pounds per foot ice load. Following this criterion the cribs in cofferdam E with 25-foot stop logs adjacent have a width to height ratio of 1 to 1.25.

(c) Crib Construction. - The cribs in the Long Sault Dam are not high, averaging only about 35 feet, and it is considered that 10-foot pockets using 10" x 10" timber make an economical combination of low material quantities and low handling costs. Weight pockets will be provided at each corner floored with a layer of 10" x 10" timbers. The cribs will be tailored to fit the bottom; clearances of one foot vertical and five feet horizontal will be used to insure good fit. No special boltings will be required in the dry face as the cribs are shallow and the rock fill will arch. 30" x 7/8" square drift pins will be used in a 15 16" hole; 2 pins across all joints.

(d) No sheathing is to be provided except on the water face where an earth blanket is required for seal.

(e) First Stage Cofferdams. - Cofferdam A is located at the upstream end of Cut G in order that most of Cut G can be made in the dry. Cofferdam A is a rock and earth fill. The section shown on the plans indicated rock to elevation 175 or normal water surface on the downstream side and earth fill above and upstream of the rock. The Massena Diversion Weir will be closed and raised at the time of closure of Cofferdam A and only leakage through the rock weir will be diverted through Cut C. The top of the cofferdam will be elevation 192. A cutoff trench to rock at the upstream toe is provided.

(f) The inside face of the center arm of Cofferdam B is located 50 feet out from the north face of Pier Monolith 14. The angle point is located 200 feet downstream from the axis of the dam to provide sufficient room for constructing the bucket and for additional working area. The south end of Cofferdam B where it joins the bank has been located so that the toe of the inside slope (1 on 3) of the shore fill will clear the end of the training wall excavation.

(g) It is proposed to set cribs 12 to 21 on rock and provide a steel pile seal in this vicinity where high velocities will exist.

(h) The blanket adjacent to an overlapping the steel sheet pile seal at cribs 12 to 21 will be protected by rock riprap.

(i) Second Stage Cofferdam. - Cofferdam 'E' is located about 1,200 feet upstream of the control on Long Sault Rapids. The rough water and high velocities immediately at and above the control make it more practical to place the cofferdam upstream in deeper water where velocities are lower. The estimated mean velocity at the proposed site is 10 feet per second. An additional advantage of placing the cofferdam upstream is the fact that the control for the rapids below the cofferdam decreased the drop through the stop log openings during placement of cribs and stop-logs.

(j) It is proposed to place all cribs adjacent to the stop-log openings on rock, which is at or only a few feet below the river bottom except on the Long Sault Island end and where some excavation will be required.

(k) Two stop-log slots are to be provided at each stop-log closure. Ordinary concrete stop-logs are proposed and, it is contemplated, will be used in the downstream slot leaving the upstream slot available for emergency closure with a girder frame and vertical needles. This method of closure may prove valuable for use where the bottom is very rough.

(l) Cofferdam 'DU'. - The portion of the second step downstream cofferdam upstream from Cofferdam B is made of the upstream and downstream bulkheads, the completed spillway, and cribs 22 to 27 of Cofferdam 'B'. Cribs 24 to 27 and the shore fill will be raised from elevation 188 to elevation 205.

(m) The first step construction blanket on cribs 24 to 27 will be removed to provide drainage and an impervious blanket will be placed on the opposite side for the second step construction. The timber bulkhead sections will be constructed in the dry within the first step cofferdam area and therefore have been sealed with a built up waterproof diaphragm.

(n) Cofferdam DD. - The second step cofferdam connecting with Crib B-17 of Cofferdam B, consists of cribs D1 to D25 across the main channel. This line of cribs has been off-set at Cribs B-15 to B-17 in order to set the long line of cribs back from the high velocity flow through the diversion openings in the dam. Cribs D-20 to D-25 will be seated on rock and have a steel sheet pile diaphragm joined to the first step sheet piling at Crib B-16. At the time Cribs B-14 and B-15 are placed in the first step a steel sheet pile membrane will be placed between them to form a link in the second step seal. Cribs 1 to 19 of Cofferdam DD will be placed on the river bottom and will be made water tight by means of an impervious blanket. It is possible that a large counter-eddy will tend to erode this blanket, and it is therefore contemplated that rock riprap will be placed on top of the blanket.

14-07. OVERBURDEN AND BEDROCK CONDITIONS AT COFFERDAMS AND CUTS.

(a) General. - The overburden in the vicinity of the cofferdams and cuts as determined by the investigations described in Section XII consists generally of glacial till underlying scattered superficial aluvial deposits. The classification of the overburden at each drill hole is shown on Sheets BD-1-1/6, 1/7, and 1/8, of the contract drawings. The glacial till is compact well graded clayey to silty gravelly sand with occasional cobbles and boulders. The glacial till in the vicinity of Cut F is extremely compact and it is estimated that the material has a unit wet weight of 150 pounds per cu. ft. The glacial till at the other sites in general is less compact than at Cut F. All glacial till may be considered impervious and unstratified, however, pockets of more pervious material may occur in the deposits.

(b) At the sites of the cofferdams, the glacial till in the river channels is overlain with deposits of variable sand, gravel and boulder to depths varying in general from 2 to 10 feet. The superficial deposits at Cofferdam 'DD' may be considerably deeper. The superficial deposits in the river channels are believed to be loose and relatively pervious to the underlying glacial till.

(c) Superficial deposits of clay or uniform sands occur at Cut G, on the east and west sides of Long Sault Island at Cut F, and at the right abutment of Cofferdam 'E'. These deposits in general are less than 10 feet in depth. The left abutment at Cofferdam 'E' is composed of artificial fill material of the present Cornwall Canal. In Cut C, the overburden to a depth of approximately 20 feet overlying glacial till is in general soft silty clay.

(d) The bed rock in the vicinity of the sites for the cofferdams and cuts is the sam formation and has the same characteristics as described in paragraph 13-02. Plate XII-1 shows the rock contours as determined from the investigations described in Section XII. The bedrock in the vicinity of Cut 'C' and 'G' is in general at elevation 160 and is believed to be below the proposed bottom elevation of these cuts. At cut F the bedrock is in general below 170 except along the north side where it may rise a few feet above elevation 170.

14-08. AVAILABILITY AND CHARACTERISTICS OF FILL MATERIALS FOR COFFERDAMS.

(a) Earth Fill. - The materials for the earth fills for the cofferdams will be obtained from the excavation for the cuts and from borrow areas shown on Plate XII-1. The earth fill material will consist of well-graded clayey or silty gravelly sand and in general will contain at least 25 percent by dry weight passing the No. 200 sieve. The material will be sufficiently impervious to prevent appreciable seepage through the cofferdam above the foundation. Material from the superficial surface deposits of clay and uniform sand which occur in the areas of the cuts will not be used unless it can be mixed with more suitable material.

(b) Rock Fill. - Material for rock fill will be obtained from structure excavations and from rock quarries. During the investigations for concrete aggregates (see paragraph 12-03) all existing exposures of rock in the vicinity were located. The nearest areas of extensive outcrops are in the channel on the north side of Barnhart Island and 2½ miles north of Mille Roche. There are several possible quarry sites accessible to a railroad in the United States within 15 miles. All bed rock and boulders in the vicinity are considered satisfactory for rock fill.

14-09. BACKWATER STUDIES FOR DIVERSION.

(a) General. - Backwater computations were made using friction values (Manning's 'n') of 0.04 for open channels and 0.025 for cuts. The channel value was based on computations over an average reach and is in reasonable agreement with values obtained by Hugh L. Cooper in 1920, which range from 0.025 to 0.06 for specific short reaches.

(b) Available data on which to base computations showed water surface relations between gages at rather widely spaced intervals but did not indicate local variations over individual reaches between gages. The following paragraphs describe the computations made for determination of water surface elevations during the second step diversion.

(c) To extend Massena Supply Weir rating curve to above 40,000 c.f.s., elevations of weir crest and ice sluice were determined. This was accomplished by plotting curves for various differences between weir crest and ice sluice elevations, with the lowest point on each curve representing water surface at weir crest elevation. These were superimposed in turn on the weir rating curve for November-December 1923, at which time the weir was shown by a St. Lawrence River Power Company curve to be in approximately the same condition as in 1939. It was found that the rating curve was fitted best by the curve for 9.5 feet difference. Curves for greater difference were steeper and curves for less difference were less steep. With the 9.5 feet curve superimposed on the rating curve the lowest point is at elevation 200.5. Therefore weir crest elevation is 200.5 and ice sluice elevation is 200.5 - 9.5 or 191.0. Water surface elevations above weir were then computed for various discharges using equation: $Q=2.63(80(W.S.+H_v-191.0)^{3/2}+450(W.S.+H_v-200.5)^{3/2}+400(W.S.+Hv-207.8)^{3/2})$.

(d) Backwater curves were then run from the weir to Richard's Bay for each of these discharges, in each case assuming 20,000 c.f.s. in Massena Power Canal. This determined a rating curve at Richard's Bay plotted against South Sault discharge between Richard's Bay and Massena Power Canal, for the "Weir in" condition.

(e) Starting at elevation 195.0 at Long Sault Dam Site, backwater curves were run up South Sault to the mouth of Cut F for 200,000 c.f.s. and 280,000 c.f.s, since that part of South Sault below Cut F carries the total river discharge during second step construction. From each of these two elevations at mouth of Cut F, various discharges were computed up South Sault to Richard's Bay; assuming the weir out and 20,000 c.f.s. in Massena Power Canal in each case. This determined two more rating curves at Richard's Bay, plotted against South Sault discharge between Richard's Bay and Massena Power Canal, one for "weir out" with river discharge = 200,000 c.f.s., and one for "weir out" with river discharge = 280,000 c.f.s.

(f) To determine division of flow between Croil Island North and South Channels, Discharge in Big Sny was computed for natural conditions for total river flows of 200,000 c.f.s. and 280,000 c.f.s., using the water surface elevations at gages 48 and 46 taken from the natural rating curves for these two gages. These discharges were found to be 109,000 c.f.s. and 170,000 c.f.s. respectively. Using the corresponding water surface elevations at gage 50 for natural conditions and the weir equation above-mentioned, discharges in lower South Sault for natural conditions were then computed. These were found to be 8,000 c.f.s. and 23,000 c.f.s. respectively. Then assuming discharge in Massena Power Canal = 20,000 c.f.s., for 200,000c.f.s. total river flow the discharge above Massena Power Canal = 28,000 c.f.s. and the discharge in Long Sault North Channel = 172,000 c.f.s. North Croil Island Channel discharge therefore is 172,000 - 109,000 = 63,000 c.f.s. and South Croil Island Channel discharge is 28,000 + 109,000 = 127,000 c.f.s. For total river flow of 280,000 c.f.s. the discharge above Massena Power Canal -43,000 c.f.s. and discharge in Long Sault Island North Channel = 237,000 c.f.s. North Croil Island Channel discharge equals 237,000 - 170,000 = 67,000 c.f.s. and South Croil Island Channel discharge = 43,000 + 170,000 = 213,000 c.f.s. Making adjustments to show more increase in North Croil Island Channel discharge with increasing total river flow, the division of flow between Croil Island North and South Channels is taken to be 50,000 c.f.s. and 150,000 c.f.s. respectively when the total river flow is 200,000 c.f.s., and 80,000 c.f.s respectively when the total river flow is 280,000 c.f.s. Since these computations were made it has been discovered that the division of flow at the

head of Croil Island was determined by observation to be 97,000 c.f.s. in North Channel and 153,000 c.f.s. in South Channel for a river discharge of 250,000 c.f.s. showing that the assumed division was in error by approximately 11 percent of the total discharge. This error will have a negligible effect on the water surface profiles.

(g) Starting from each of the two elevations previously determined at the mouth of Cut F for total river flows of 200,000 c.f.s. and 280,000 c.f.s., backwater curves were run through Cut F for various discharges. In each case the velocity head was added to the water surface elevation obtained at the head of Cut F to obtain the water surface elevation at Lock 21, thereby assuming that whatever velocity head exists at Lock 21 will be consumed in friction head between Lock 21 and the head of Cut F. The water surface elevation was assumed to be the same at the mouth of big Sny as at Lock 21, thereby assuming that whatever velocity head recovery was obtained at the mouth of Big Sny was consumed in friction head between the mouth of Big Sny and Lock 21. Since the heads involved are small, these assumptions are not far in error. Subtracting 50,000 c.f.s. or 80,000 c.f.s. as the case may be, for North Croil Island Channel discharge, the remainder was computed through Big Sny and Little Sny to Richard's Bay, assuming the velocity head to be constant throughout. The elevations thereby obtained at Richard's Bay were plotted against the corresponding discharges in South Sault between Richard's Bay and Massena Power Canal, on the same sheet with the South Sault curves. These points determined two curves, one for 200,000 c.f.s. total river flow and one for 280,000 c.f.s. total river flow. The intersection of each of these curves with the South Sault "weir in" curve gives the South Sault discharge above Massena Power Canal for 200,000 c.f.s. and 280,000 c.f.s. total river flows when the weir is in. These were found to be 38,000 c.f.s. and 63,000 c.f.s respectively, or 18,000 c.f.s. and 43,000 c.f.s. lower South Sault discharge. The intersections of the North Sault curves with the corresponding South Sault "weir out" curves gives the South Sault discharge above Massena Power Canal for 200,000 c.f.s. and 280,000 c.f.s. total river flows when the weir is out. These were found to be 65,000 c.f.s. and 95,000 c.f.s. respectively, or 45,000 c.f.s. and 75,000 c.f.s. lower South Sault discharge.

(h) The submergence of the ice sluice was found to not exceed 67 percent for any of the conditions considered.

14-10. SPILLWAY.

(a) The primary criterion for the establishment of the elevation of the spillway crest was that it should pass the maximum January flow (220,000 c.f.s.) at the minimum pool elevation (elev. 231). The minimum pool of 231.0 would have occured in January 1936 with a flow of 192,000 under regulation plan number 5. The maximum January flow of 221,000 would have occurred in January 1862 under regulation plan number 5. A spillway designed for the maximum ultimate pool elevation of 242.5, and having a crest elevation 221, satisfied this criterion and the crest elevation was established at elevation 221.

(b) The crest curve of $x^2 = 47Y$, designed for 21.5 foot head, was later revised to $x^{1.82} = 32.53Y$ to obtain stability in the section. This reduced the discharge at elevation 231 to 211,000 c.f.s. or conversely, raised the headwater elevation necessary to obtain a discharge of 220,000 by 0.3 feet.

(c) Spillway discharge was computed from the formula $Q = CLeH^{3/2}$, 'C' being a coefficient varying with the head over the crest and 'Le' being the effective length. The Creager & Justin coefficients, given on page 133 of their Hydro-Electric Handbook were used. The effective length (Le) was computed from the equation Le = L-(knH), 'k' being a constant varying from 0.03 to 0.10 for different pier nose shapes (used herein as 0.05) and 'n' being the number of contractions. The spillway rating curve is shown on Plate XIV-17.

14-11. STILLING DEVICES. - No studies have been made for the dimensions and characteristics of the apron and/or stilling devices below the spillway, although it is anticipated that a simple bucket type apron will be provided. In the event that the dam is approved for construction, model studies will be made to determine the most satisfactory apron.

ANALYSIS OF DESIGN FOR LONG SAULT DAM.

SECTION XIV
EXHIBIT I

December 18, 1940

Subject: Hydraulic Data and Results obtained from Canadian Engineers.

1. A considerable amount of work in connection with compilation of hydraulic data has been done by the Canadian Engineers, particularly by Mr. Guy F. Lindsay of the Department of Transport. This memorandum summarizes portions of the data furnished which it is believed will be of general interest:

RELATION BETWEEN PRECIPITATION AND SUPPLIES TO THE GREAT LAKES

2. Description of Watershed. The drainage areas, water surface areas and the equivalent in cubic feet per second per month of one foot storage of each of the Great Lakes are as follows:-

Lake	Drainage Area	Water Surface Area	Equivalent of 1 foot storage per month
	sq. miles	sq. miles	c.f.s.
Superior	80,900	31,820	337,300
Michigan-Huron	147,880	45,410	481,300
Erie	34,680	9,940	105,400
Ontario	34,630	7,540	79,900
Totals	298,090	94,710	1,003,900

3. Precipitation. The Controller of the Meteorological Division of the Air Services Branch of the Department of Transport has prepared data on the precipitation on the watershed of the Great Lakes extending from 1871 to 1938, inclusive. In compiling this data, the watershed was divided into sections, the precipitation in each section obtained by taking the mean of the precipitation reported from all stations in the section, and the precipitation on the total watershed was based on the weighted mean of that in each section. The total number of stations from which records were available varied from 22 in 1871 to 177 in 1919.

4. Table No. 1, attached hereto, shows the total precipitation for each climatic year, i.e., November 1 to October 31, from 1871 to 1938. This is also shown in diagrammatic form on Diagram No. 2190. The total annual precipitation has varied from a maximum of 39.69 inches in 1879-80 to a minimum of 25.90 inches in 1894-95. The average over the whole period has been at the rate of 31.22 inches.

5. Supply. The annual net supply to the entire Great Lakes System, from 1860 to 1939, has varied from a maximum of 339,000 c.f.s. in

1873 to a minimum of 149,000 c.f.s. in 1895, with an average for the entire period of 238,000 c.f.s.

6. The seasonal variation in supply swings between wide limits, being highest in the spring months and lowest in the fall. The average monthly net supply by months, from 1860 to 1939, has been as follows:

Spring and Summer		Fall and Winter	
March	373,000 c.f.s.	August	165,000 c.f.s.
April	530,000 "	September	83,000 "
May	532,000 "	October	40,000 "
June	423,000 "	November	28,000 "
July	290,000 "	December	64,000 "
		January	113,000 "
		February	215,000 "
Average	430,000 c.f.s.	Average	101,000 c.f.s.

7. The maximum monthly net supply was at the rate of 829,000 c.f.s. during May, 1916. During November 1867, the draw on storage in the lakes was 175,000 c.f.s. in excess of the net supply.

8. Relation between Net Supply and Precipitation. The period from 1871 to 1938 has been divided into the periods from which the following data, showing the relation between supply and precipitation to the Great Lakes, has been deduced.

	Period 1871 to 1905	Period 1905 to 1938
Average annual net supply	242,000 c.f.s.	229,000 c.f.s.
Total annual precipitation	31.99 inches	30.43 inches
" " "	702,000 c.f.s.	668,000 c.f.s.
Net supply as percent of precipitation	34.4%	34.3%

REGULATION OF LAKE ONTARIO

9. "A number of studies have been made by several engineers on the regulation of Lake Ontario in connection with the development of power on the St. Lawrence and these studies * * * * * * show that the benefit to power operation obtained by any of them is not great." (Joint Board Report 1926.)

10. Mr. Lindsay, in his recent studies, used the same basic data as the Joint Board, increasing the net supply as computed by 10,300 c.f.s. to compensate for the reduction of the diversion at Chicago from 8,500 c.f.s. (assumed by the Board) to 3,200 c.f.s. (present diversion) and the addition of 5,000 c.f.s. from the Ogaki River and Long Lac watersheds into Lake Superior as contemplated by Ontario. Mr. Lindsay also used the "Discharge - Stage Relation - ships" for the various locks (copies of which were attached to a memorendum from Mr. Lindsay to the District Engineer, dated September, 1940) and data obtained from the U. S. Lake Survey water levels at Oswego

referred to the 1935 datum.

The following essential requirements for the regulation of Lake Ontario were used by the Joint Board:

(a) To keep the fluctuations of the levels of Lake Ontario within the levels that it has had in the past.

(b) To maintain, without impairment, the low water levels of Montreal Harbour.

(c) To maintain low flows during the winter period December 15 to March 31, in order that the difficulties of winter operation may not be aggravated.

(d) To maintain flows during the first half of April no greater than would naturally occur, in order to avoid the danger of aggravating the spring rise during the breakup of the ice below Montreal.

(e) To avoid any material increase in the amount and duration of the high discharges during May in order not to aggravate high water heights in Lake St. Louis during the Ottawa floods.

(f) To hold back the natural excess outflow during the early summer months, in order to raise the ordinary levels of Lake Ontario.

(g) To secure the maximum dependable flow throughout the year for power operation.

To these requirements Mr. Lindsay added the following additional one:

(h) To keep the fluctuation in monthly mean discharges within the limits as existed in nature.

11. Rule curves were established for various operation schedules and applied to conditions as existing in the past in an attempt to meet all regulation requirements but in general it was found that one requirement could be completely satisfied only at a sacrifice in the degree to which others were met. Of all the schedules and variations studied, the adopted schedule, identified as Method No. 5, seemed to best meet all requirements.

12. By the application of Method No. 5 to the corrected values of the net supply, Mr. Lindsay has computed monthly mean discharges and lake levels for the period 1860 to 1939. On Plate A are shown the Discharge Duration Curves, Curve A being for natural Conditions and Curve B for requlation under Method No. 5.

The mean and extremes compared with actual is as follows:

	Regulated Method No. 5	Actual
Mean discharge	242,000 c.f.s.	237,000 c.f.s.
Minimum monthly discharges	180,000 " (Nov. 1939)	144,000 "
Maximum " "	310,000 "	314,000 "
Mean lake level	246.43 ft.	245.96 ft.
Minimum monthly mean	244.73 ft.(Nov. 1934)	242.68 ft.
Maximum monthly mean	249.10 ft.(May 1870)	249.02 ft.

BACKWATER CALCULATIONS AND HYDRAULICS

13. Backwater computations have been made for both open water and ice conditions to determine the slope required for a given discharge and lake level, and from this information and the regulated flow, according to Method No. 5, the head and tailwater elevations and the head and power available have been calculated for each month from 1860 to 1939. This information has been summarized in the form of curves on the attached sheets:

Plate B. "Power and Head Duration Curves".

Plate C. "Envelope of Minimum and Maximum Heads and Power available for various Discharges and Percent of Time".

14. Profiles indicating natural water surface profiles and the extremes of the calculated backwater profiles are shown in:

Plate D. "Tentative Backwater Profiles".

15. In computing the available head during the winter months, it was necessary to make certain assumptions as to ice conditions and effects of ice conditions. Mr. Lindsay assumed "that the backwater slopes during January and February would be those resulting from ice cover conditions; during April to December 15th open water conditions; and during March and the second half of December the average of open water and ice cover conditions.

16. "It was (also) assumed (by Mr. Lindsay) that during January and February the tailwater levels would rise 5 feet above open water conditions and during March and the second half of December tailwaters would be an average of open and ice conditions. Plate E shows the tailwater curve for both open water and for assumed ice cover conditions."

WAR DEPARTMENT
UNITED STATES ENGINEER OFFICE
MASSENA, N.Y.

SUBJECT St. Lawrence River Project - Long Sault Dam

COMPUTATIONS Electrical Power Distribution System SHEET ... OF ... SHEETS

COMPUTED BY RMO CHECKED BY ... DATE 8/15/41

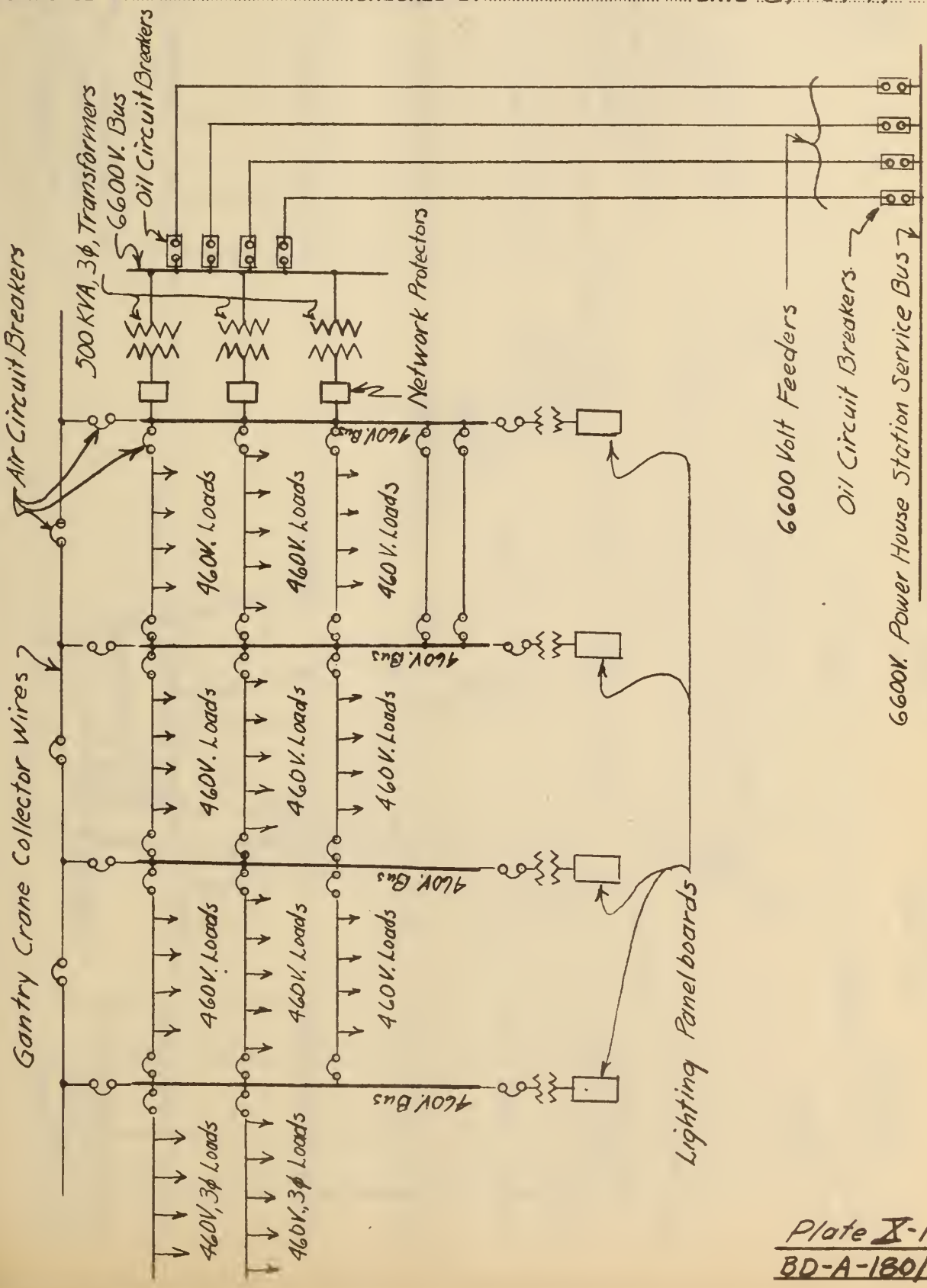
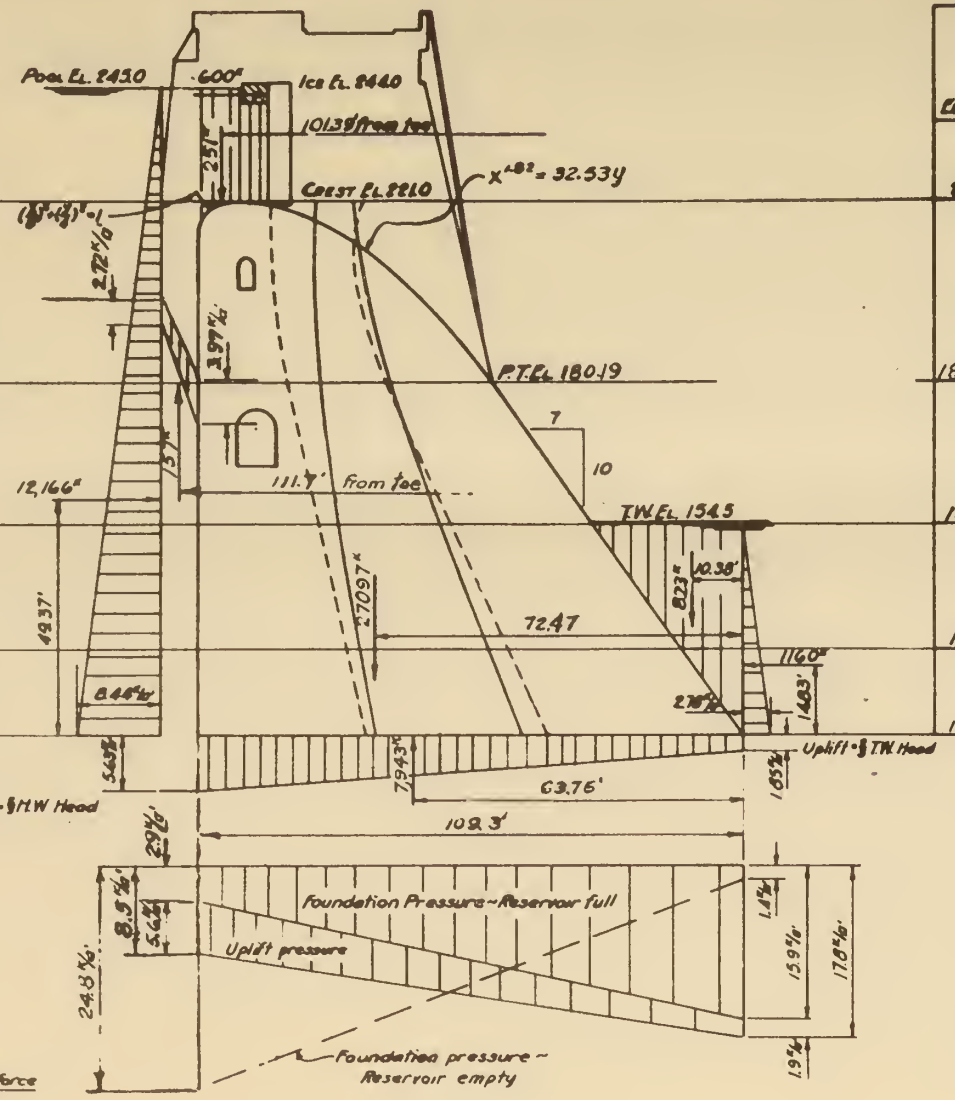


Plate X-1
BD-A-180/1

Condition of Reservoir			
Full	Empty		
S_v	S_v	Position of Resultant	Elev.
Lbs. per sq. in.			
15	51	+9.66'	221
*-5	90	+4.63	180.19
32	123	+2.37	154
45	154	+1.08	128
52	173	+0.65	110



Elev.	Condition of Reservoir					
	Full					Empty
	Position of Resultant	Sliding Factor	M_R/M_O	S_v	S_s	S_v
				Lbs. per sq. in.		
221	+1.34	0.46	1.0	89	23	55
180.19	**-1.03	0.47	2.9	105	28	27
154	+1.43	0.53	2.3	105	29	12
128	+2.98	0.58	1.9	119	35	5
110	+3.55	0.58	1.7	133	38	3

STABILITY FACTORS

Stresses at Upstream Face

* Minus sign indicates tension

STABILITY FACTORS

Stresses at Downstream Face

** Minus sign indicates that the resultant falls outside the middle third

LEGEND

Limits of middle third — — — —

Position of resultants ————

NOTATION

S_v = Vertical stress

S_s = Shear stress on horizontal plane = $\frac{\text{Horizontal force}}{\text{Area}}$

Sliding factor = $\frac{\text{Horizontal force}}{\text{Weight - Uplift}}$

$\frac{M_R}{M_O}$ = Safety factor against overturning = $\frac{\text{Resisting moment}}{\text{Overturning moment}}$

SCALE

0 5' 10' 15' 20' 40'

ST LAWRENCE RIVER

LONG SAULT DAM

ANALYSIS OF DESIGN

STABILITY ANALYSIS

20' PIER MONOLITH

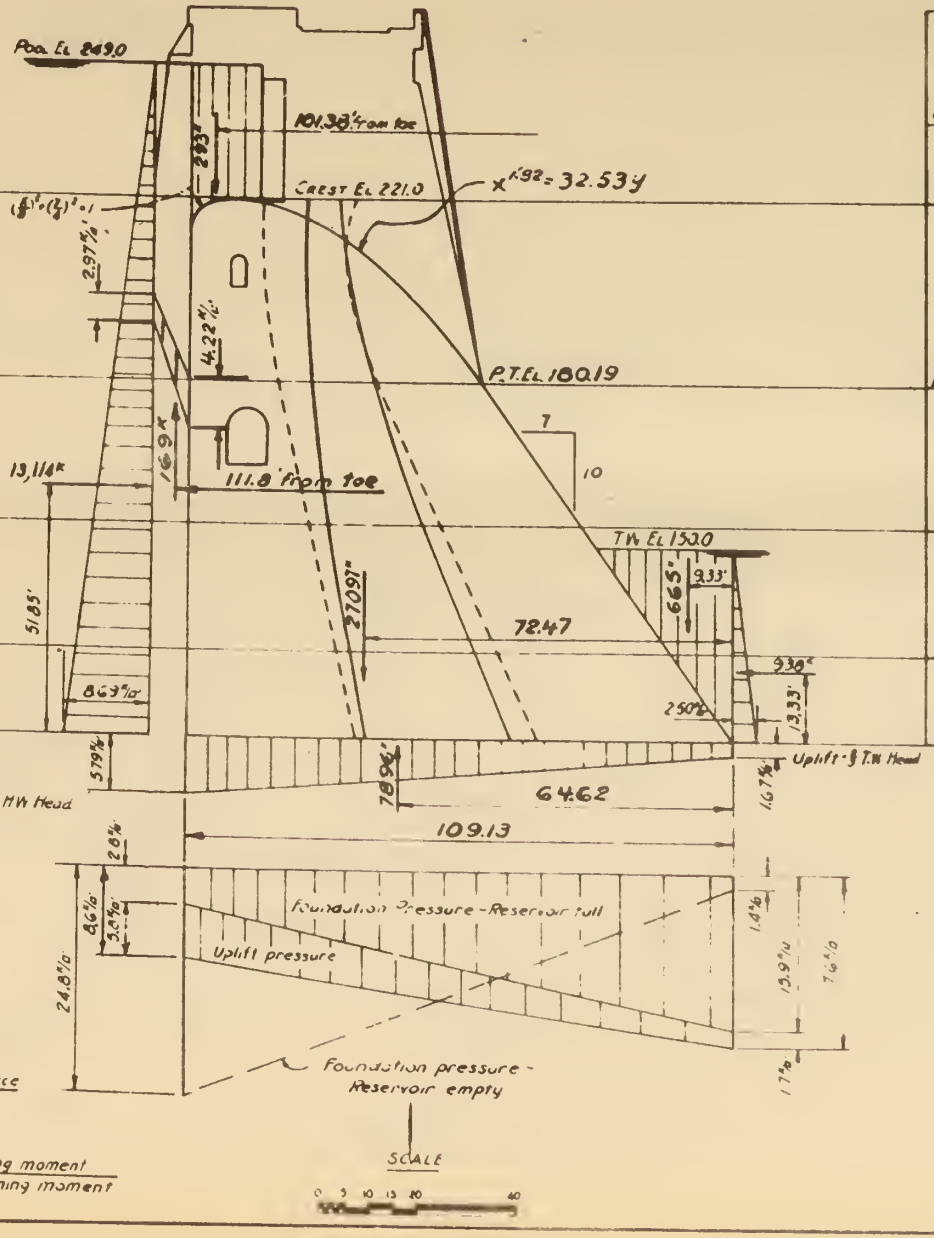
BD-A-151

PLATE XI-1

Condition of Reservoir			
Full	Empty		
S_v	S_s	Point of Resultant	Elev
LBS PER SQ IN			
28	51	+9.86	221
22	90	+4.63	180.19
37	123	+2.37	154
47	154	+1.08	128
52	173	+0.65	110

STABILITY FACTORS

STRESSES AT UPSTREAM FACE



Elev.	Condition of Reservoir					
	Full					Empty
	Position of Resultant	Sliding Factor	M_r/M_o	S_v	S_s	S_v
				LBS PER SQ IN		
221	+3.51	0.40	9.2	77	20	55
180.19	+0.35	0.47	3.0	97	23	27
154	+2.21	0.55	2.3	101	30	12
128	+3.21	0.60	2.0	117	36	5
110	+3.34	0.61	1.7	138	40	2

STABILITY FACTORS

STRESSES AT DOWNSTREAM FACE

LEGEND

Limits of middle third — — — —

Position of resultants ————

NOTATION

S_v = Vertical stress

S_s = Shear stress on horizontal plane = $\frac{\text{Horizontal force}}{\text{Area}}$

Sliding factor = $\frac{\text{Horizontal force}}{\text{Weight - uplift}}$

$\frac{M_r}{M_o}$ = Safety factor against overturning = $\frac{\text{Resisting moment}}{\text{Overturning moment}}$

ST LAWRENCE RIVER

LONG SAULT DAM

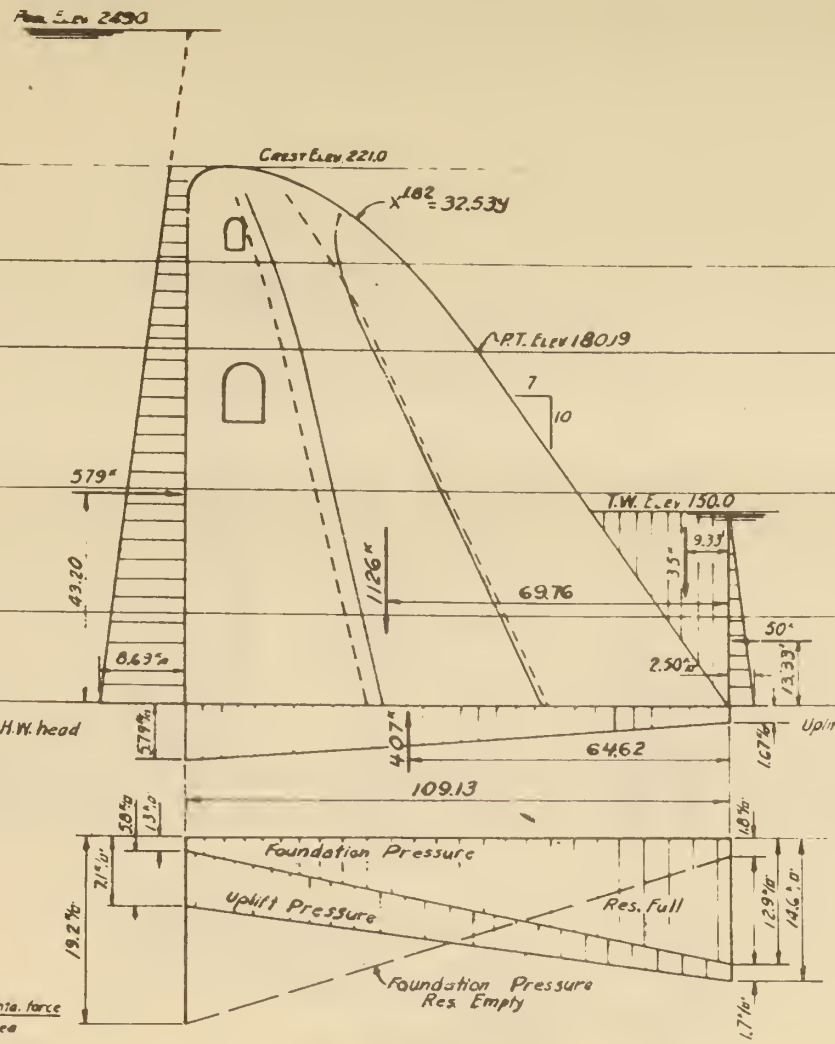
ANALYSIS OF DESIGN

STABILITY ANALYSIS

20' PIER MONOLITH

BD-A-15/2

PLATE XI-2



Condition of Reservoir			
Full			Empty
S_z	S_s	Position of Resultant	S_z
lbs per sq. ft			lbs per sq. ft
* -1	23	- 2.80	201
23	48	- 3.28	180.19
30	77	- 3.62	154
38	110	- 3.23	128
43	132	- 2.99	110

Elev.	Condition of Reservoir					
	Full					Empty
	Position of Resultant	Sliding Factor	M_R/M_o	S_z	S_s	S_z
				lbs per sq. ft		
201	** -1.03	1.08	1.4	15	8	5
180.19	- 1.76	0.76	1.6	34	14	9
154	- 0.88	0.73	2.0	60	23	12
128	1.09	0.72	1.7	86	30	12
110	- 1.05	0.70	1.6	105	34	12

STABILITY FACTORS
Stresses at Upstream Face

* Minus sign indicates tension

STABILITY FACTORS
Stresses at Downstream Face

** Minus sign indicates that the resultant falls outside the middle third

LEGEND
Limit of middle third — — — — —
Position of resultants ———

NOTATION
S_z = Vertical stress

S_s = Shear stress on horizontal plane = $\frac{\text{Horizontal force}}{\text{Area}}$

Sliding factor = $\frac{\text{Horizontal force}}{\text{Weight - Uplift}}$

M_R/M_o = Safety factor against overturning = $\frac{\text{Res. stab. moment}}{\text{Overturning moment}}$

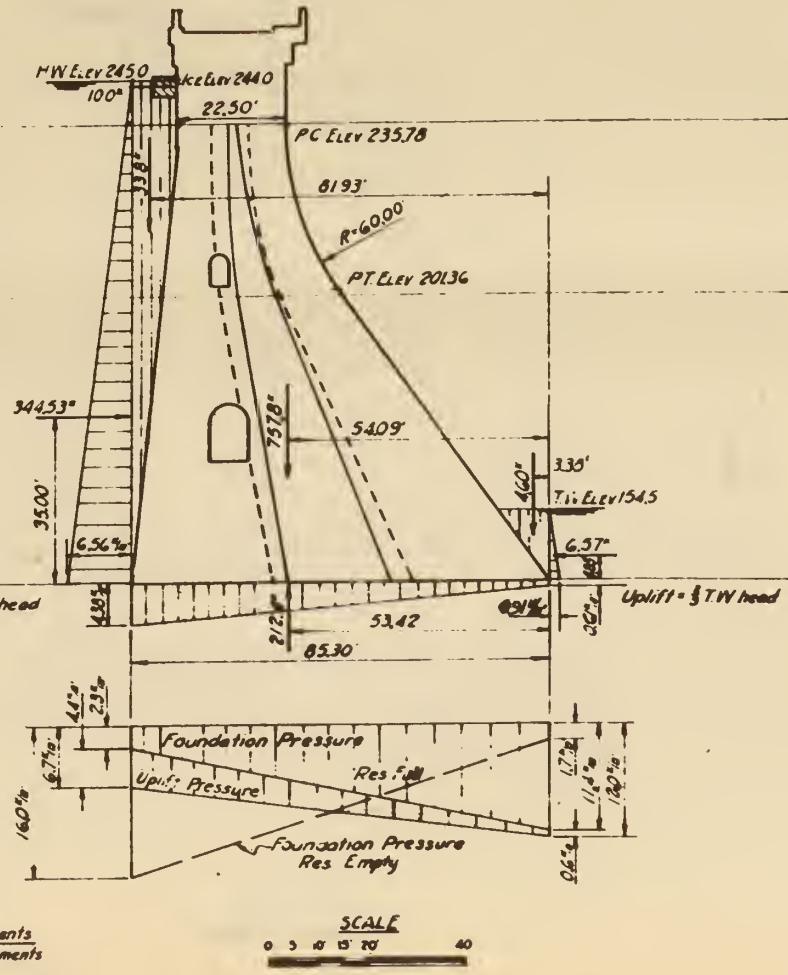
SCALE
0 5' 10' 15' 20' 40'

ST LAWRENCE RIVER
LONG SAULT DAM
ANALYSIS OF DESIGN
STABILITY ANALYSIS
SPILLWAY MONOLITH
FORCES ARE ON ONE FOOT OF LENGTH
BD-A-15/3

PLATE XII - 3

Condition of Reservoir			
Full	Empty		
S_v	S_s	Position of Resultant	Elev
lbs per sq in			
13	21	+3.75	236
19	37	+3.51	200
.46	111	+2.78	140

STABILITY FACTORS
Stresses at Upstream Face



Elev	Condition of Reservoir					
	Full					Empty
	Position of Resultant	Sliding Factor	M_e/M_o	S_r	S_s	S_r
				lbs per sq in		
236	+2.20	0.19	5.3	29	4	21
200	+1.15	0.40	2.1	62	14	22
140	-4.73	0.60	1.8	84	28	12

STABILITY FACTORS
Stresses at Downstream Face

LEGEND
Limit of middle third - - - -
Position of resultants ———

NOTATION

S_v = Vertical stress

S_s = Shear stress on horizontal plane = $\frac{\text{Horizontal force}}{\text{Area}}$

Sliding factor = $\frac{\text{Horizontal force}}{\text{Weight} \cdot \text{Uplift}}$

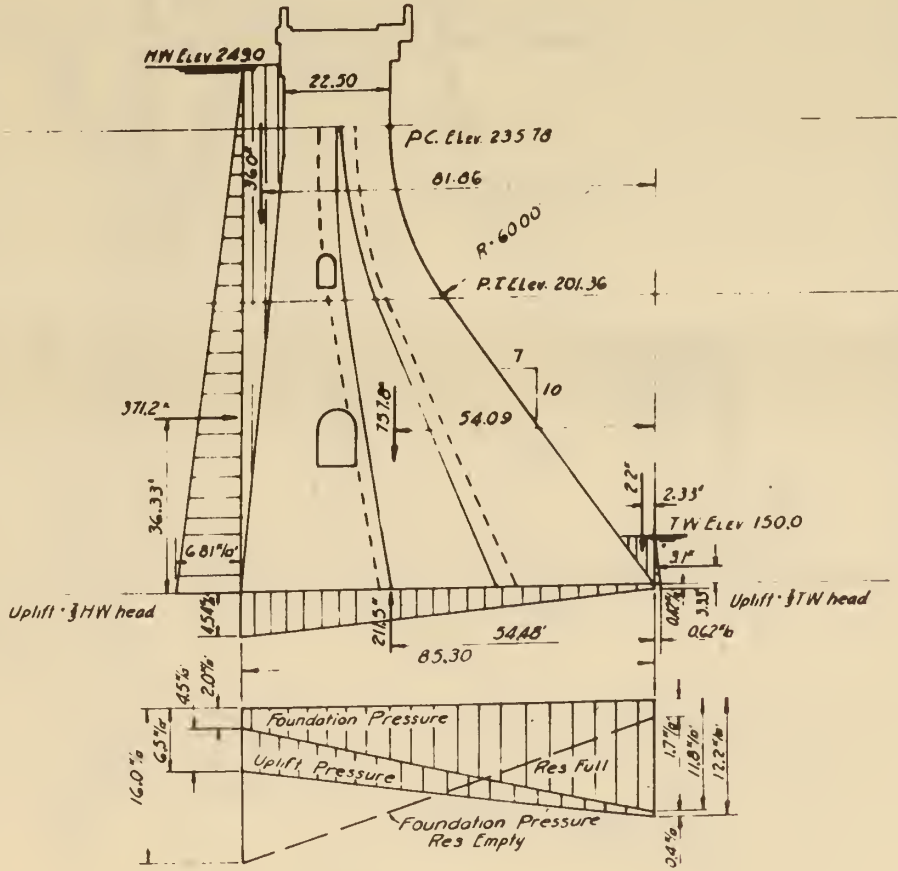
M_e/M_o = Safety factor against overturning = $\frac{\text{Resisting moments}}{\text{Overturning moments}}$

ST LAWRENCE RIVER
LONG SAULT DAM
ANALYSIS OF DESIGN
STABILITY ANALYSIS
SOUTH BULKHEAD
FORCES ARE ON ONE FOOT OF LENGTH
BD-A-15/4

PLATE XI-4

Condition of Reservoir			
Full	Empty		
S_s	S_v	Position of Resultant	Elev
lbs per sq in			
80	21	+3.75	236
89	37	+3.31	200
45	111	+2.78	140

STABILITY FACTORS
STRESSES AT UPSTREAM FACE



Elev	Condition of Reservoir					
	Full					Empty
	Position of Resultant	Sliding Factor	M_s/M_o	S_v	S_s	S_v
				lbs per sq in		
236	+3.04	0.00	7.0	24	2	21
200	+2.70	0.40	2.1	55	14	22
140	+.398	0.63	1.8	85	30	12

STABILITY FACTORS
STRESSES AT DOWNSTREAM FACE

LEGEND

Limit of middle third — — — —
Position of resultants ——— –

NOTATION

S_v = Vertical stress

S_s = Shear stress on horizontal plane = $\frac{\text{Horizontal Force}}{\text{Area}}$

Sliding factor = $\frac{\text{Horizontal Force}}{\text{Weight - Uplift}}$

M_s/M_o = Safety factor against overturning = $\frac{\text{Resisting Moments}}{\text{Overturning Moments}}$

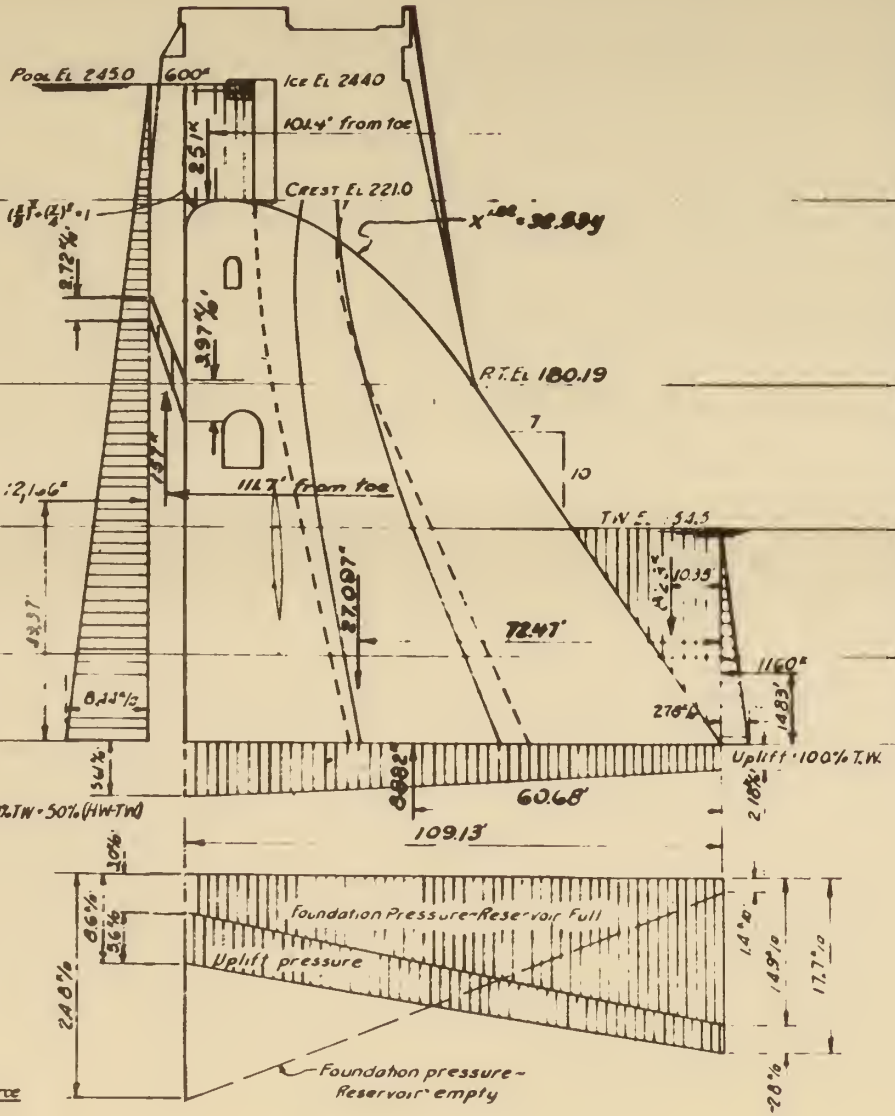
SCALE

0 5 10 15 20 40

ST LAWRENCE RIVER
LONG SAULT DAM
ANALYSIS OF DESIGN
STABILITY ANALYSIS
SOUTH BULKHEAD
FORCES ARE ON ONE FOOT OF LENGTH
BD-A-15/5

PLATE XI-5

Condition of Reservoir			
Full	Empty		
S_v	S_v	Position of Resultant	Elev
lbs per sq in.			
15	51	+3.86	221
-1/8 *	90	+4.63	180.19
32	123	+2.37	154
45	134	+1.08	128
52	173	+0.65	110



Elev.	Condition of Reservoir					
	Full					Empty
	Position of Resultant	Sliding Factor	M_R/M_O	S_v	S_s	S_v
				lbs. per sq in		
221	+1.66	0.45	9.1	88	23	53
180.19	-0.08 **	0.45	3.3	105	23	27
154	+2.82	0.50	2.6	105	29	12
128	+3.77	0.58	1.9	119	35	5
110	+3.81	0.61	1.6	133	38	3

STABILITY FACTORS

Stresses at Upstream Face

Uplift = 100% T.W. + 50% (H.W.-T.W.)

* Minus sign indicates tension

STABILITY FACTORS

Stresses at Downstream Face

** Minus sign indicates that the resultant falls outside the middle third

LEGEND

Limits of middle third — — — —

Position of resultants ———

NOTATION

S_v = Vertical stress

S_s = Shear stress on horizontal plane = $\frac{\text{Horizontal force}}{\text{Area}}$

Sliding factor = $\frac{\text{Horizontal force}}{\text{Weight - Uplift}}$

$\frac{M_R}{M_O}$ = Safety factor against overturning = $\frac{\text{Resisting moment}}{\text{Overturning moment}}$

SCALE

0 5 10 15 20 40

ST. LAWRENCE RIVER
LONG SAULT DAM
ANALYSIS OF DESIGN
STABILITY ANALYSIS
20' PIER MONOLITH

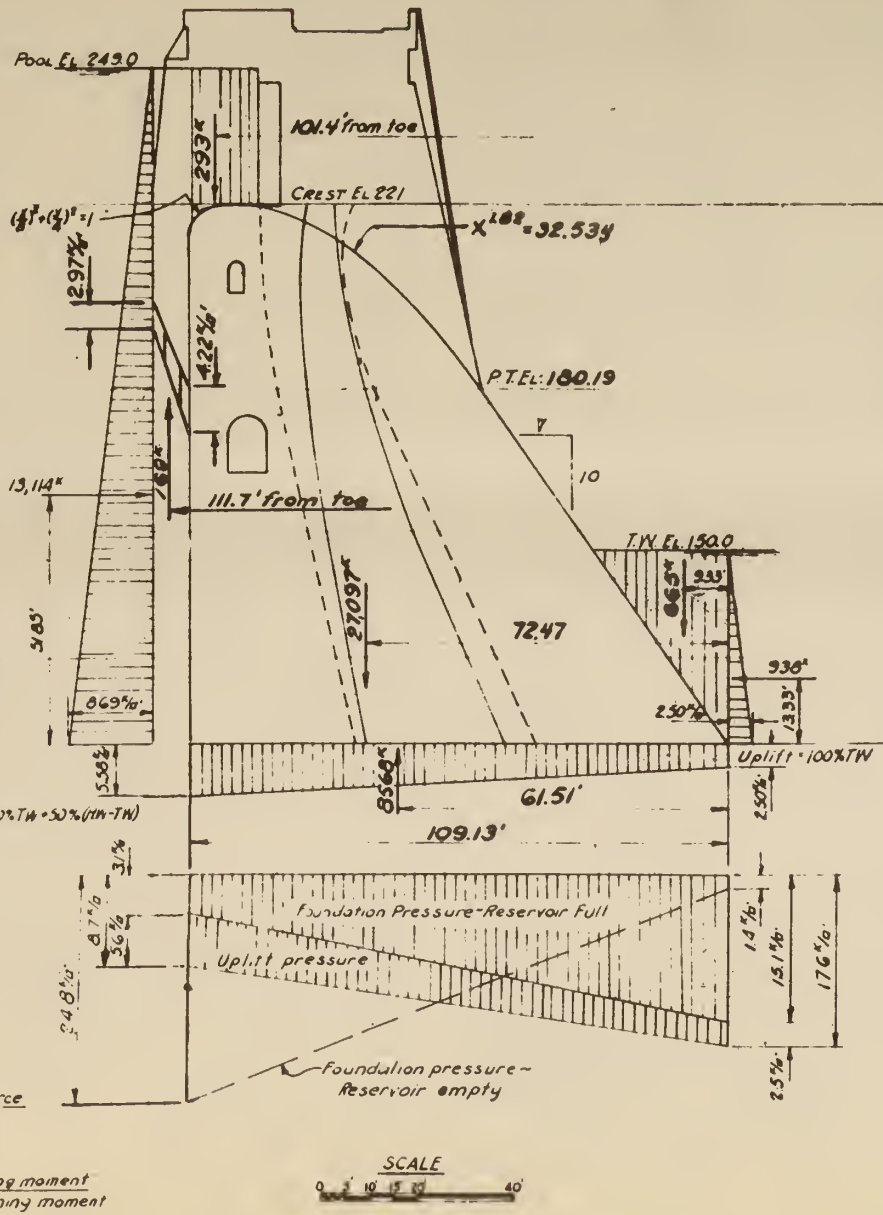
BD-A-15/6

PLATE XII - 6

Condition of Reservoir			
Full	Empty		
S_v	S_v	Position of Resultant	Elev
lbs per sq in			
28	51	+.986	221
22	90	+4.63	180.19
36	123	+2.37	154
47	154	+1.08	128
52	173	+.065	110

STABILITY FACTORS

STRESSES AT UPSTREAM FACE



Uplift = 100% TW + 50% (HW-TW)

Elev.	Condition of Reservoir: Full — Position of Resultant	Sliding Factor	M_a/M_o	S_v lbs. per sq. in.	S_s lbs. per sq. in.	Empty: S_v lbs. per sq. in.
221	+.386	+0.40	10.9	76	20	55
180.19	+1.30	0.45	3.4	97	23	27
154	+.359	0.52	2.7	101	30	12
128	+4.23	0.60	1.9	116	36	5
110	+.387	0.63	1.6	132	40	3

STABILITY FACTORS

STRESSES AT DOWNSTREAM FACE

LEGEND

Limits of middle third — — — — —

Position of resultants ———————

NOTATION

S_v = Vertical stress

S_s = Shear stress on horizontal plane = $\frac{\text{Horizontal force}}{\text{Area}}$

Sliding factor = $\frac{\text{Horizontal force}}{\text{Weight - Uplift}}$

$\frac{M_a}{M_o}$ = Safety factor against overturning = $\frac{\text{Resisting moment}}{\text{Overturning moment}}$

SCALE

0 5 10 15 20 40

ST. LAWRENCE RIVER

LONG SAULT DAM

ANALYSIS OF DESIGN

STABILITY ANALYSIS

20' PIER MONOLITH

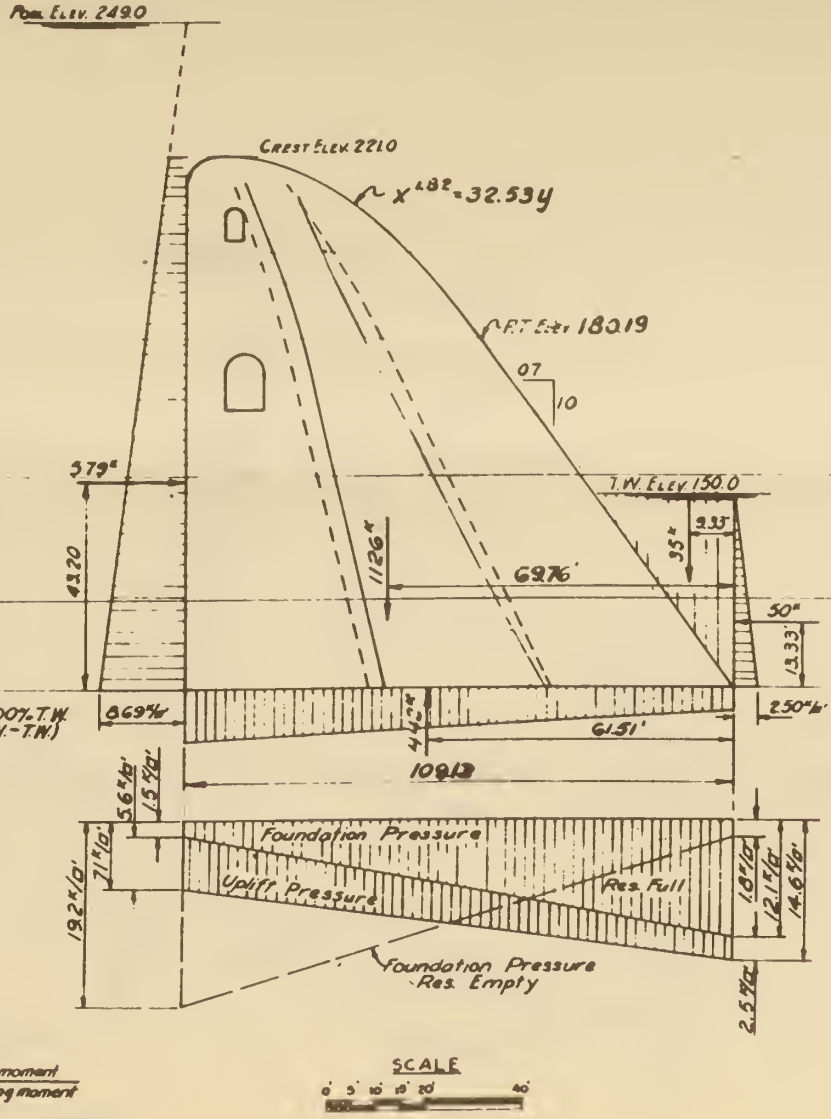
BD-A-15/7

PLATE XI-7

Condition of Reservoir			
Full	Empty		
S_v	S_s	Position of Resultant	Elev
lbs per sq in			
13	23	+2.80	201
23	48	+3.28	180.19
30	77	+3.62	154
38	110	+3.23	128
43	132	+2.99	110

STABILITY FACTORS

STRESSES AT UPSTREAM FACE



SCALE

0 5 10 15 20 40

NOTATION

S_v = Vertical stress

S_s = Shear stress on horizontal plane

Sliding factor = $\frac{\text{Horizontal force}}{\text{Weight} - \text{Uplift}}$

M_e/M_o = Safety factor against overturning = $\frac{\text{Resisting moment}}{\text{Over turning moment}}$

Elev	Condition of Reservoir: Full — Position of Resultant	Full — Sliding Factor	Full — M_e/M_o	Full — S_v	Full — S_s	Empty — S_v
				lbs per sq in		
201	+2.00	0.87	1.7	15	8	5
180.19	+3.88	0.67	1.9	34	14	9
154	+3.38	0.66	2.4	60	23	12
128	+2.60	0.72	1.8	86	30	12
110	+1.65	0.74	1.5	105	34	12

STABILITY FACTORS

STRESSES AT DOWNSTREAM FACE

LEGEND

Limit of middle third – – – – –

Position of resultants ———

ST LAWRENCE RIVER

LONG SAULT DAM

ANALYSIS OF DESIGN

STABILITY ANALYSIS

SPILLWAY MONOLITH

FORCES ARE ON ONE FOOT OF LENGTH

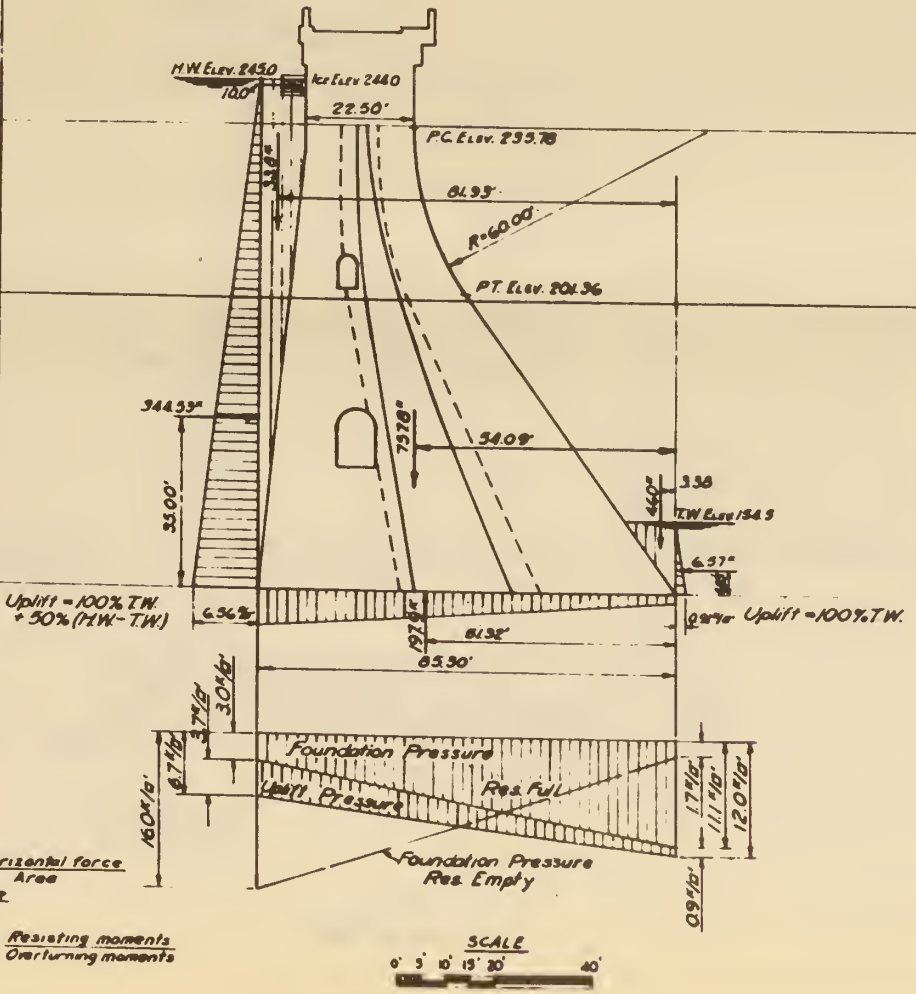
BD-A-15/8

PLATE XII-8

Condition of Reservoir			
Full	Empty		
S_v	S_v	Position of Resultant	Elev
lbs. per sq. in.			
15	21	+3.75	236
19	57	+3.31	200
46	111	+2.78	140

STABILITY FACTORS

Stresses at Upstream Face



Elev	Condition of Reservoir					
	Full					Empty
	Position of Resultant	Sliding Factor	M_e/M_o	S_v	S_s	S_v
				lbs. per sq. in.		
236	+ 2.28	0.19	59	29	4	21
200	+ 1.66	0.30	23	62	14	22
140	+ 5.92	0.58	19	83	25	12

STABILITY FACTORS

Stresses at Downstream Face

LEGEND

Limit of middle third — — — —

Position of resultants ————

NOTATION

S_v = Vertical stress

S_s = Shear stress on horizontal plane = $\frac{\text{Horizontal force}}{\text{Area}}$

Sliding factor = $\frac{\text{Horizontal force}}{\text{Weight - Uplift}}$

M_e/M_o = Safety factor against overturning = $\frac{\text{Resisting moments}}{\text{Overturning moments}}$

SCALE

0' 5' 10' 15' 20' 40'

ST LAWRENCE RIVER

LONG SAULT DAM

ANALYSIS OF DESIGN

STABILITY ANALYSIS

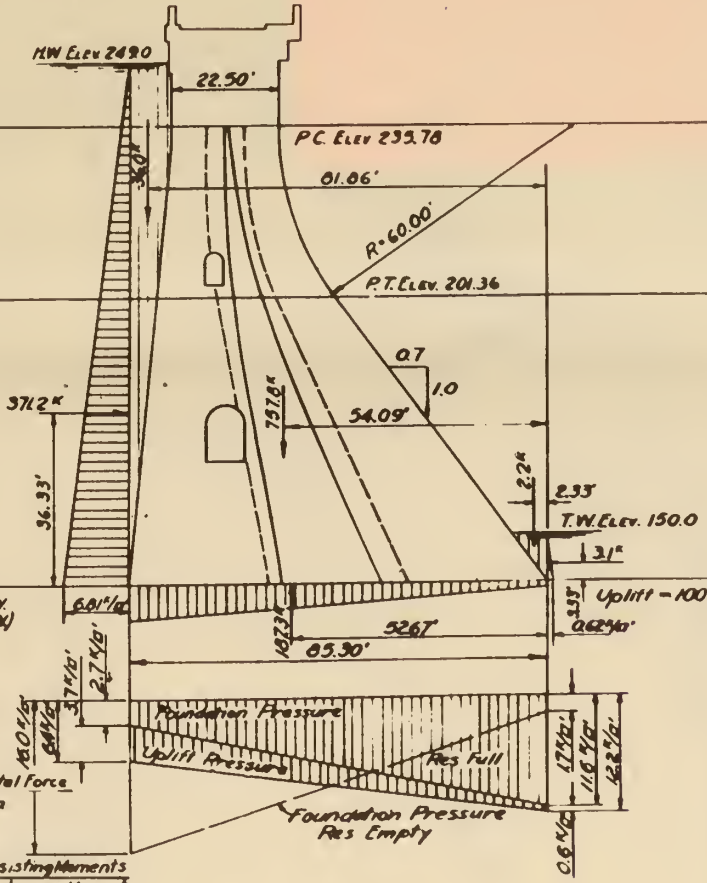
SOUTH BULKHEAD

FORCES ARE ON ONE FOOT OF LENGTH

BD-A-15/9

PLATE XI-9

Condition of Reservoir			
Full	Empty		
S_V	S_V	Position of Resultant	Elev.
Lbs. per sq. in.			
20	21	+3.75	236
29	57	+3.51	200
45	111	+2.78	140



Condition of Reservoir						
		Full				Empty
Elev.	Position of Resultant	Sliding Factor	M_R/M_O	S_V	S_S	S_V
				Lbs. per sq. in.		
236	+3.13	0.08	6.7	24	2	21
200	+3.17	0.38	2.6	55	14	22
140	+5.41	0.60	1.9	85	30	12

STABILITY FACTORS
Stresses at Upstream Face

STABILITY FACTORS
Stresses at Downstream Face

NOTATION

S_V = Vertical stress

S_S = Shear stress on horizontal plane = $\frac{\text{Horizontal Force}}{\text{Area}}$

Sliding factor = $\frac{\text{Horizontal force}}{\text{Weight - Uplift}}$

M_R/M_O = Safety factor against overturning = $\frac{\text{Resisting Moments}}{\text{Overturning Moments}}$

LEGEND

Limit of middle third — — — —

Position of resultants ————

SCALE

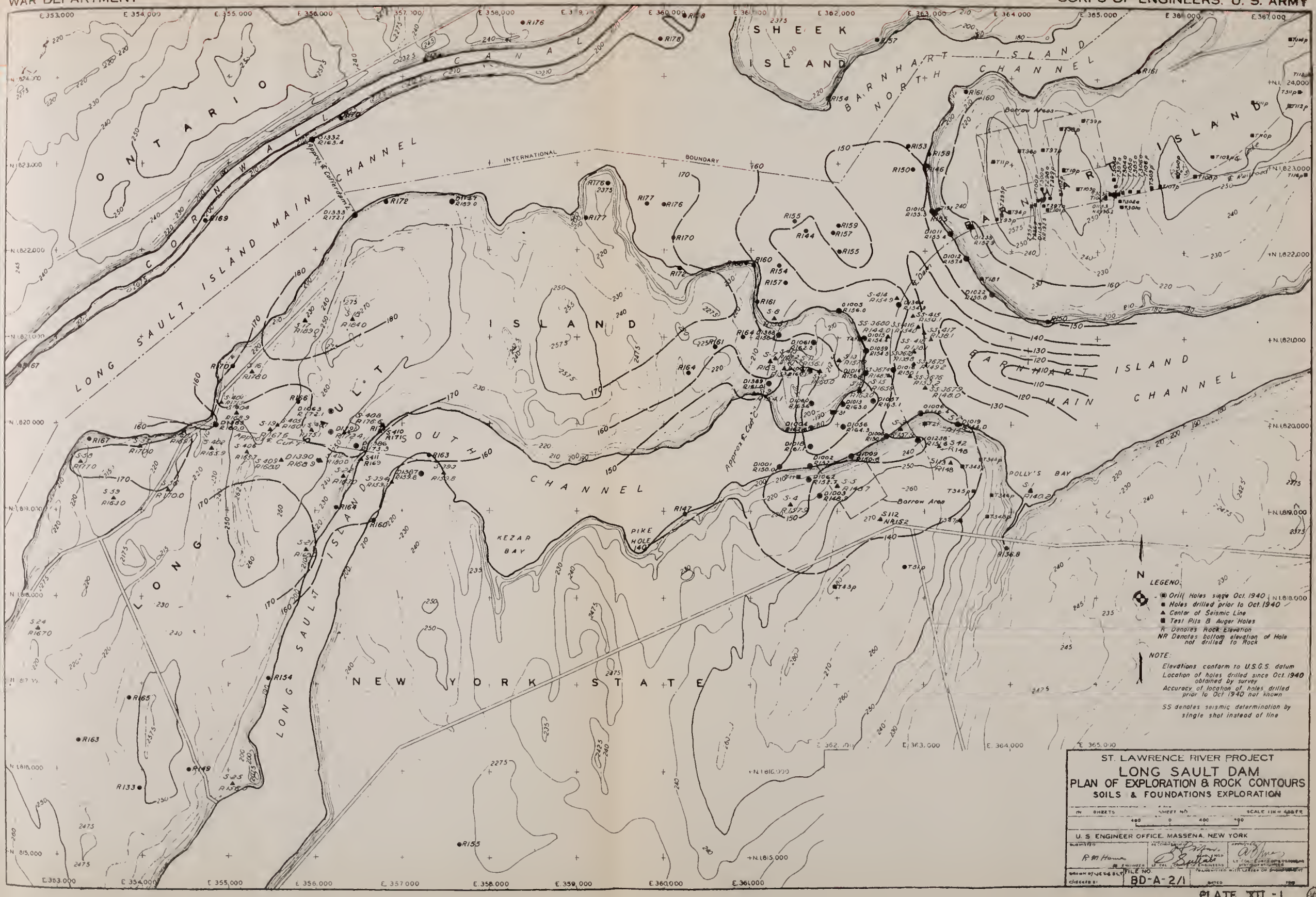
0 5' 10' 15' 20 40

ST LAWRENCE RIVER
LONG SAULT DAM
ANALYSIS OF DESIGN
STABILITY ANALYSIS
SOUTH BULKHEAD

FORCES ARE ON ONE FOOT OF LENGTH

BO-A-15/10

PLATE XI-10



LEGEND:

- Drill Holes since Oct. 1940
- Holes drilled prior to Oct. 1940
- Center of Seismic Line
- Test Pits & Auger Holes

R Denotes Rock Elevation

NR Denotes bottom elevation of Hole not drilled to Rock

NOTE:

Elevations conform to U.S.G.S. datum

Location of holes drilled since Oct. 1940 obtained by survey

Accuracy of location of holes drilled prior to Oct 1940 not known

SS denotes seismic determination by single shot instead of line

ST. LAWRENCE RIVER PROJECT

LONG SAULT DAM

PLAN OF EXPLORATION & ROCK CONTOURS

SOILS & FOUNDATIONS EXPLORATION

SCALE 1 IN = 400 FT

0 400 800

U. S ENGINEER OFFICE, MASSENA, NEW YORK

DRAWN BY R. M. Hanna

CHECKED BY

FILE NO. BD-A-2/1

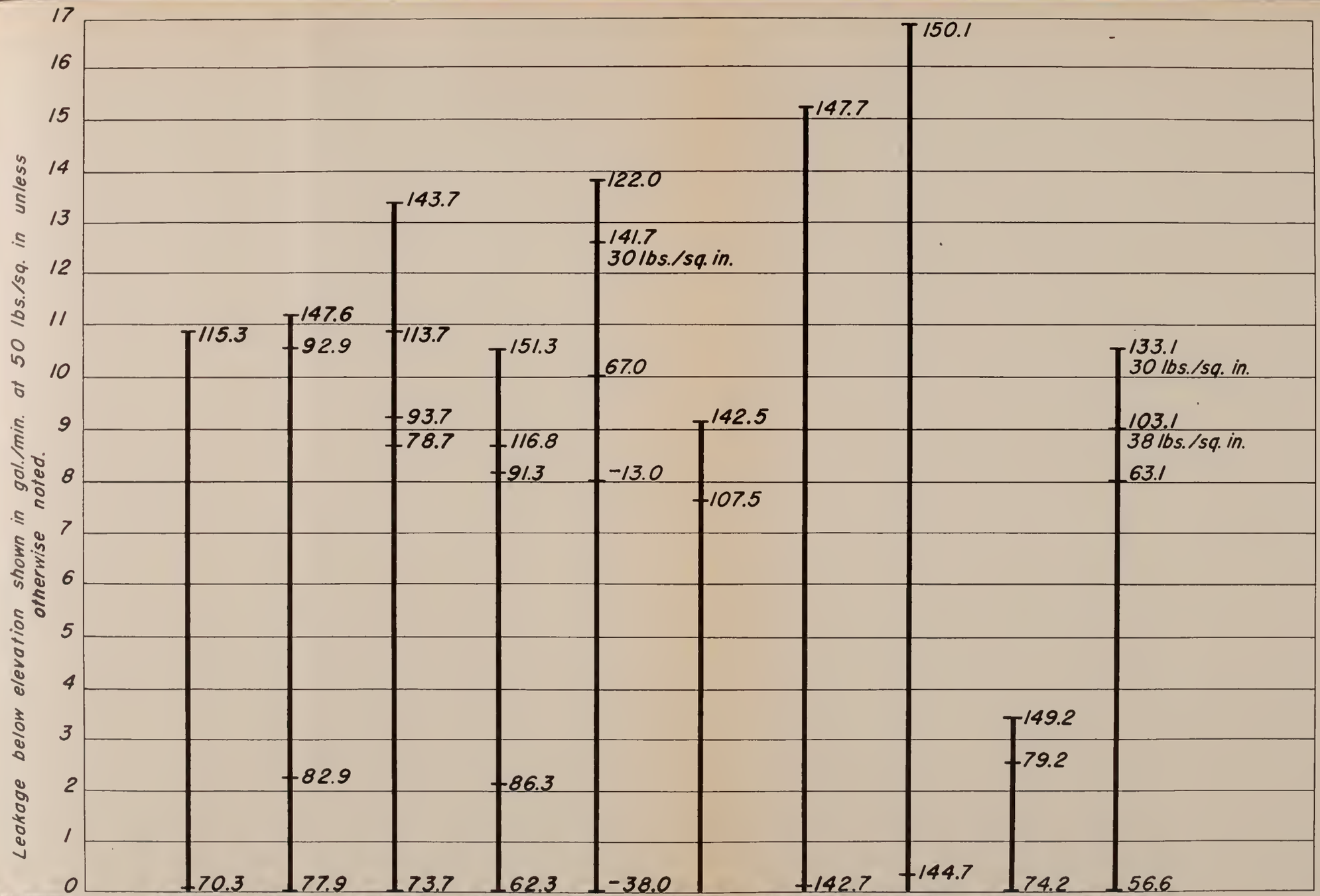
DATED 1941

PLATE XII - 1

LONG SAULT DAM SITE
RESULTS OF MOISTURE CONTENT DETERMINATIONS

Drill Hole	Sample	Elev.	Water Content % Dry Weight
D-1059	1	165.7	12.8
	2	161.7	8.7
	3	155.3	9.9
D-1133	1	217.4	6.9
	2	212.5	7.2
	4	203.2	6.4
	6	190.2	7.5
D-1134	1	223.1	10.4
	2	218.5	9.5
	3	205.2	10.5
	4	200.2	13.8
	5	195.4	38.2
D-1238	1	227.1	9.0
	2	222.6	9.8
	3	217.1	8.4
	4	212.1	10.2
	5	207.1	9.1
	6	202.1	9.0
	7	197.1	10.8
	8	192.1	10.0
	9	186.6	10.4
	10	180.1	11.0
	11	175.1	12.4
	12	170.6	8.6
	13	166.1	9.2
D-1239	1	219.4	6.0
	2	213.0	8.4
	3	205.2	8.7
	4	200.3	9.5
	6	190.0	9.1
	8	179.8	8.3
	9	173.8	8.7
	10	167.3	5.7
	11	160.0	3.7
D-1332	3	178.0	11.1
	4	171.3	8.3
D-1333	1	188.7	10.3
	2	183.7	9.0
	3	178.7	8.4
D-1364	2	164.2	16.0
D-1385	1	213.7	38.1
	4	198.7	19.3
D-1388	1	195.6	36.1
	2	190.6	53.7
	4	180.6	8.4
D-1389	1	197.8	47.1
	2	192.8	38.6
	3	187.8	61.2
	4	182.8	65.4

FILE NO.BD-A-2/2
Plate XII-2

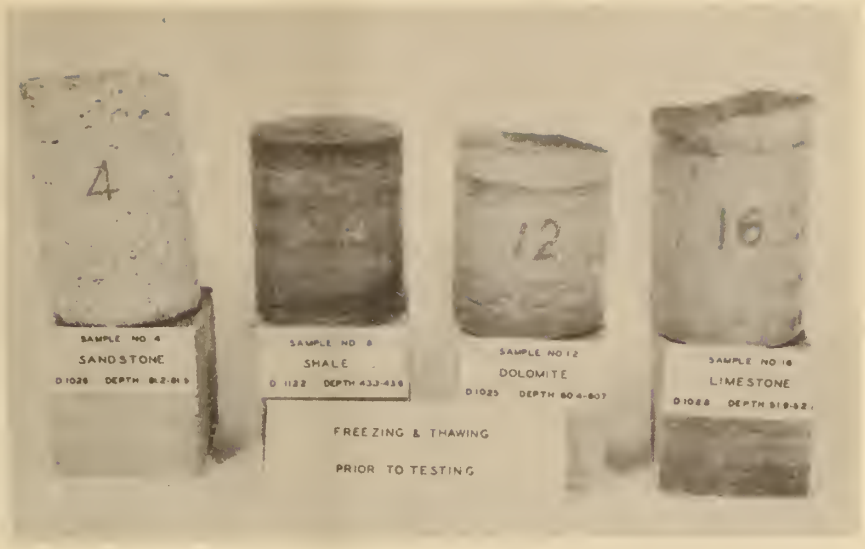


Drill Hole	D1009	D1011	D1016	D1022	D1059	D1061	D1062	D1238	D1239	D1364
Top of Rock Elev.	150.8	155.4	150.1	155.8	154.5	162.5	152.7	151.6	157.9	154.9
Bottom of Hole Elev.	50.8	54.9	48.9	55.8	-46.5	61.5	112.7	51.6	57.8	54.6

LONG SAULT DAM SITE

RESULT OF PRESSURE TEST IN ROCK

File No. 8D-A-2/3
Plate XII - 3


4
SAMPLE NO 4
SANDSTONE
12
SAMPLE NO 12
DOLOMITE
16
SAMPLE NO 16
LIMESTONE
FREEZING & THAWING
PRIOR TO TESTING

SANDSTONE
SHALE
DOLOMITE

Plate XII-4

2
10
14
SAMPLE NO. 2
SANDSTONE
D 1026 DEPTH 782-785
SAMPLE NO 6
SHALE
D 1026 DEPTH 586-589
SAMPLE NO 10
DOLOMITE
D 1026 DEPTH 955-958
SAMPLE NO 14
LIMESTONE
D 1027 DEPTH 380-382
WETTING & DRYING
"OVEN DRY"
PRIOR TO TESTING

2
10
14
SAMPLE NO 2
SANDSTONE
D 1026 DEPTH 782 785
SAMPLE NO 6
SHALE
D 1026 DEPTH 586-589
D 1026 DEPTH 955 958
D 1027 DEPTH 380 382

Plate XII-5

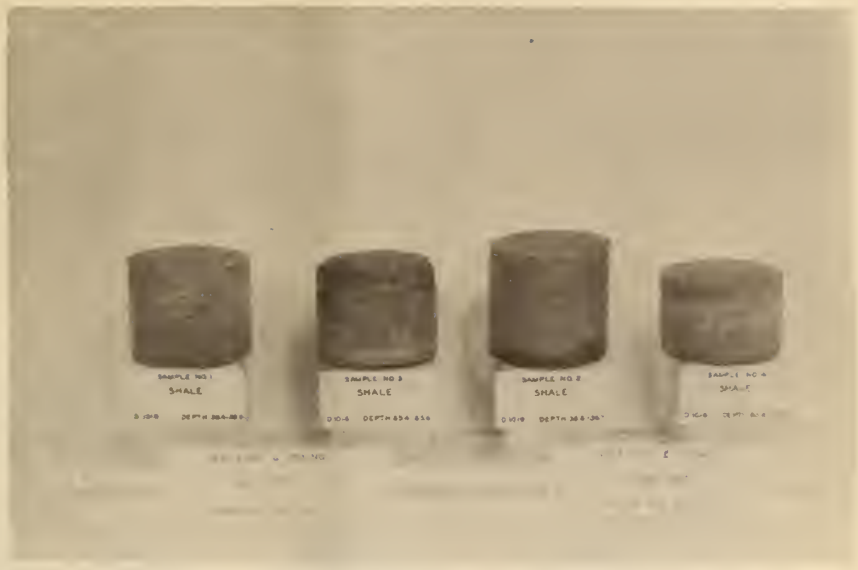
SAMPLE NO 1
SANDSTONE
D 1026 DEPTH 780-782
SAMPLE NO 5
SHALE
D 1026 DEPTH 562-564
SAMPLE NO 9
DOLOMITE
D 1026 DEPTH 917-919
SAMPLE NO 13
LIMESTONE
D 1027 DEPTH 302-304
WETTING & DRYING
"AIR DRY"
PRIOR TO TESTING

Plate XII-6

SANDSTONE
SHALE
9
DOLOMITE
13
LIMESTONE
WETTING & DRYING
"AIR DRY"
CYCLE NO 2

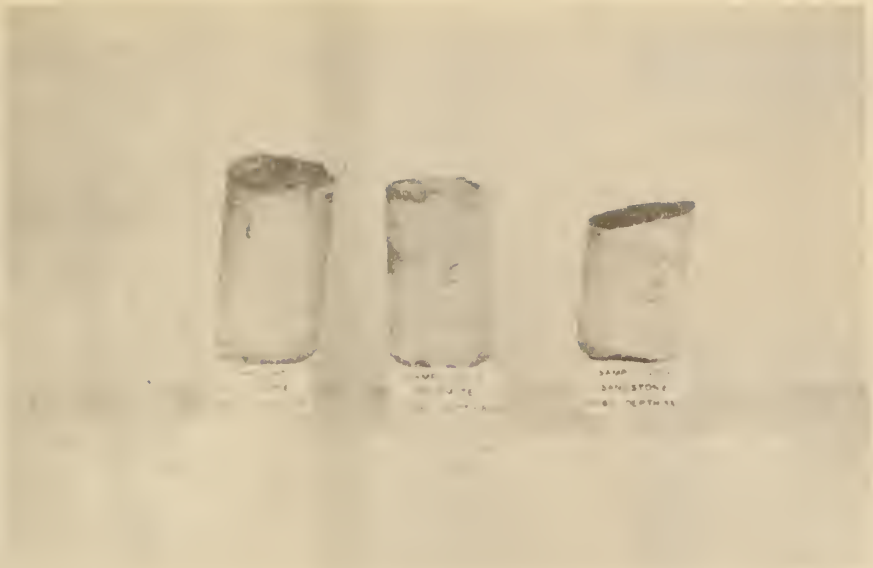
1
9
13

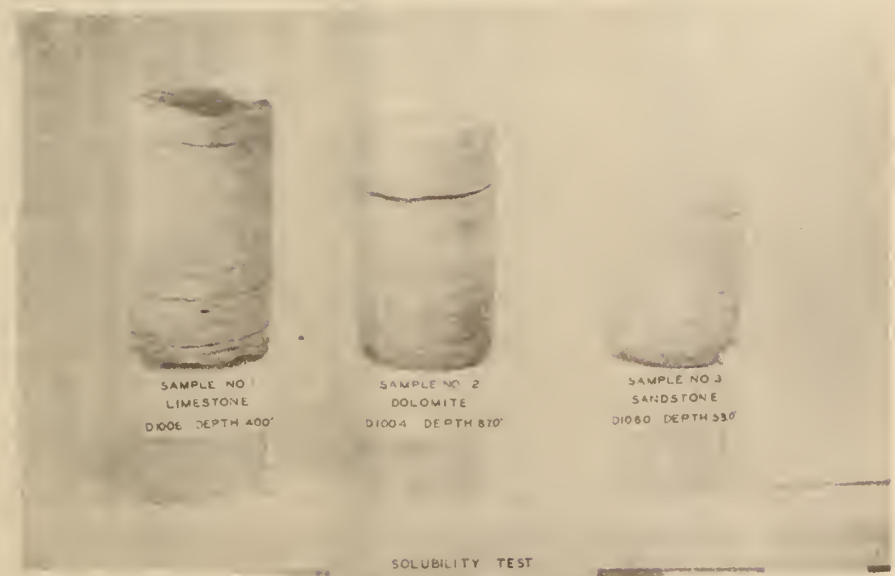
Plate XII-7



Shale Samples

Shale Samples





Samples After Test

MECHANICAL ANALYSIS

SIEVE ANALYSIS — HYDROMETER ANALYSIS

SIZE OPENING IN INCHES — NO. MESH PER INCH

100 | 28 | 16 | 8 | 4 | "A" 2 | "B" 1.03 | "C" 0.742 | "D" 0.526 | "E" 0.371 | 3 | 4 | 6 | 8 | 10 | 14 | 20 | 28 | 35 | 48 | 65 | 100 | 150 | 200 | 250 | 0

Typical Foundation Material

SITE Long Sault Dam.
HOLE .....
DEPTH .....
SAMPLES .....
PLOTTER .....
DATE .....

Curve No.	Hole No.	Sample	Depth	Elev.
	Right Abutment			
1	D1238	1	2.0'	212.4'
2	B1238	3	46.5'	1865'
	Left Abutment			
3	D1239	2	21.8'	213.0'
4	B1012	3	81'	1626'
	Dike Foundation			
5	E102.0	1	20-30'	Black Mucked
6	E304.0	1	12-16'	Clay
7	F169.0	1	15'-60'	Glacial Till

% FINER BY WEIGHT

% RETAINED

1000.0 | 500.0 | 300.0 | 200.0 | 100.0 | 50.0 | 30.0 | 20.0 | 10.0 | 5.0 | 3.0 | 2.0 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | 0.05 | 0.03 | 0.02 | 0.01 | 0.005 | 0.003 | 0.002 | 0.001 | 0.0005 | 0.0002 | 0.0001

GRAIN SIZE IN MM.

M I T SOIL CLASSIFICATION

DERRICK	ONE MAN	SMALL	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	COLLOIDAL
STONE*			GRAVEL*			SAND			SILT			CLAY		

* These sizes not included in original M.I.T. Classification

File No. BD-A-2/4 Plate XIII-1

Plate XIII-1 File No. BD-A-2/4

MECHANICAL ANALYSIS

SIEVE ANALYSIS — HYDROMETER ANALYSIS

SIZE OPENING IN INCHES — NO. MESH PER INCH

100 28 18 8 4 "A" 2 "B" 1.03 "C" 0.742 "D" 0.526 "E" 0.371 3 4 6 8 10 14 20 28 35 48 65 100 150 200 250

Typical Borrow Material

SITE Long Sault Dam
HOLE .....
DEPTH .....
SAMPLES .....
PLOTTER .....
DATE .....

Curve No.	Hole No.	Sample	Depth
1	T96p	1	20'-60'
2	T99p	1	10'-60'
3	D1062	3	135'-140'

% FINER BY WEIGHT — % RETAINED

1000.0 500.0 300.0 200.0 100.0 50.0 30.0 20.0 10.0 5.0 3.0 2.0 1.0 0.5 0.3 0.2 0.1 0.05 0.03 0.02 0.01 0.005 0.003 0.002 0.001 0.0005 0.0002 0.0001

GRAIN SIZE IN MM.

M I T SOIL CLASSIFICATION

DERRICK	ONE MAN	SMALL	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	COLLOIDAL
STONE*			GRAVEL*			SAND			SILT			CLAY		

* These sizes not included in original M.I.T. Classification

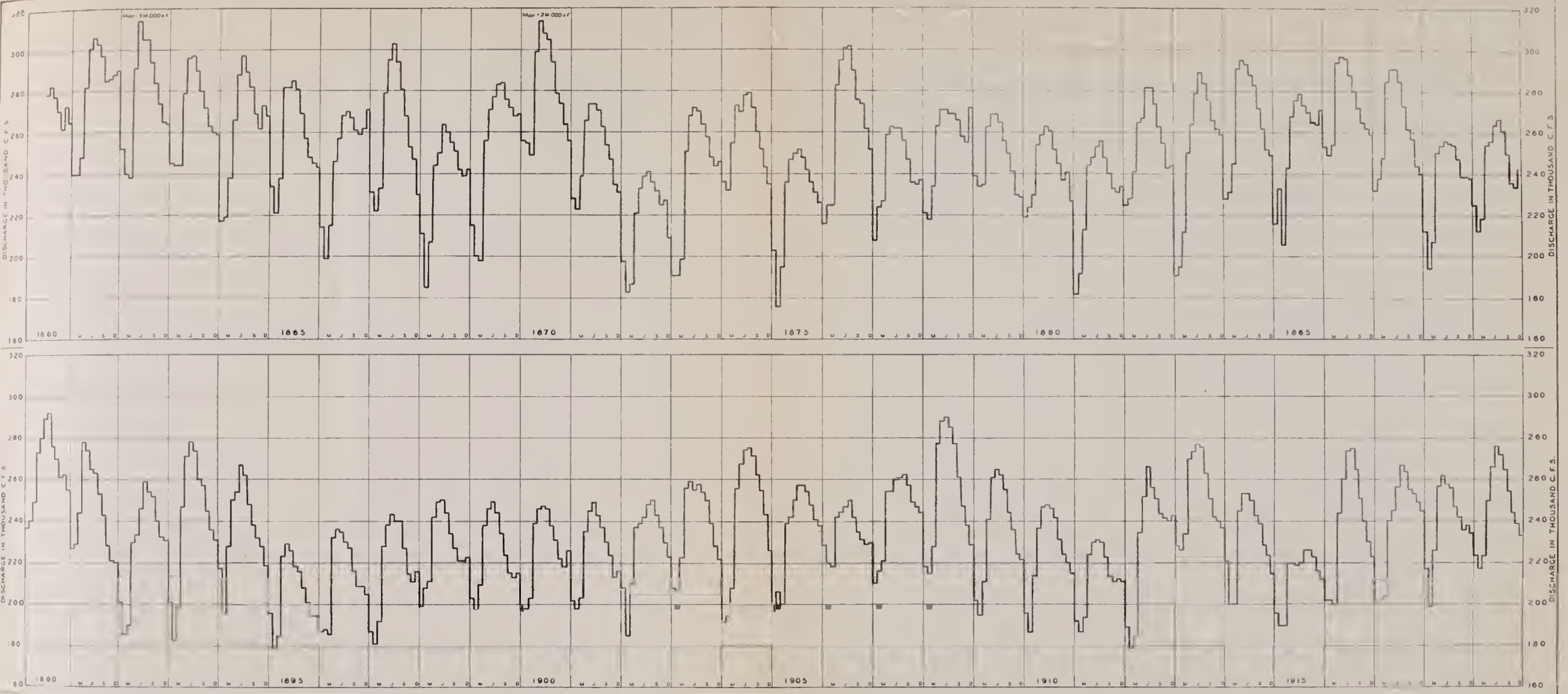
File No. BD-A-2/5 Plate XIII-2

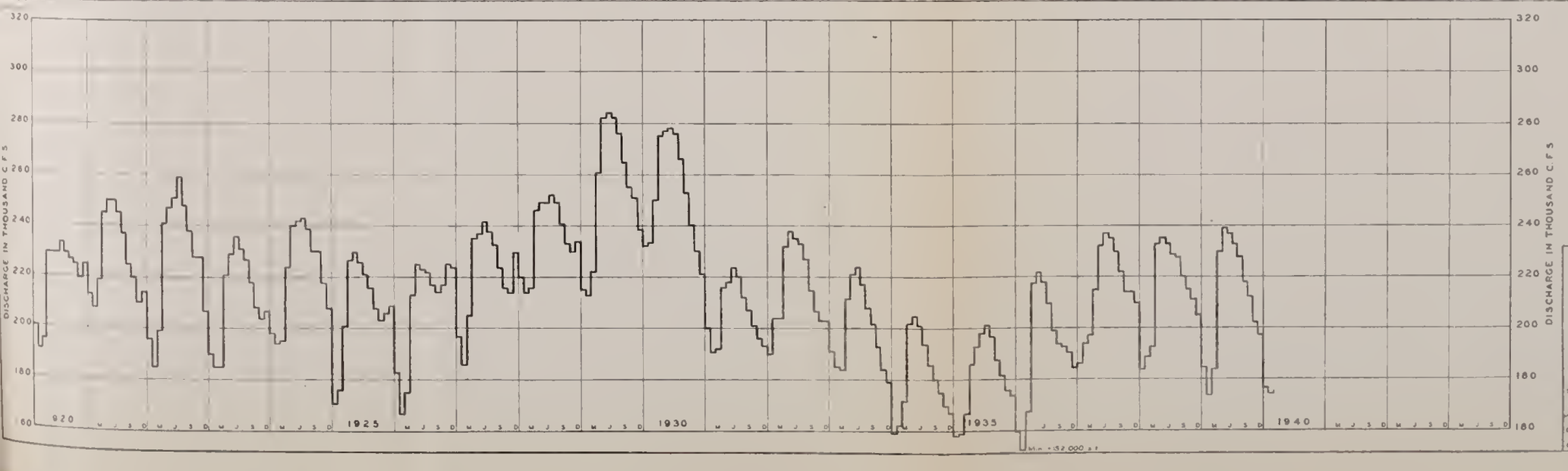
File No. BD-A-2/5 Plate XIII-2

SL - 3.00

WAR DEPARTMENT

CORPS OF ENGINEERS, U S ARMY





General Notes
Discharge data from 1860-1940 inclusive is from Table No 3 (F.H. 107 22) Dept of Transport, Ottawa, Sept 1940

ST. LAWRENCE RIVER PROJECT

MEAN MONTHLY DISCHARGES
ST LAWRENCE RIVER
1860-1941

IN 39 SHEETS SHEET NO 4

SCALE AS SHOWN

U S ENGINEER OFFICE, MASSENA, NEW YORK MAY 24 1941

SUBMITTED BY [illegible] APPROVED BY [illegible]

Leonard F. Harrison ENGINEER

DRAWN BY R.I.F. FILE NO. [illegible]

CHECKED BY L.F.H. BD-11/3

PLATE [illegible]

CANAL

CORNWALL

KINGS HIGHWAY NO. 2

LOCK 21

COFFERDAM "E"

FLOW

LONG SAULT ISLAND MAIN CHANNEL

ROAD

SAULT

CUT "F"

ISLAND

LONG

SAULT

ISLAND

SOUTH

CHANNEL

CUT "C"

EARTH COFFERDAM

COFFERDAM "D"

COFFERDAM "C"

COFFERDAM "A"

CUT "G"

COFFERDAM "B"

BARNHART ISLAND

NORTH CHANNEL

BARNHART ISLAND

BARNHART ISLAND MAIN CHANNEL

N 1822,000

N 1823,000

N 1824,000

NOTE CHANNEL DISTANCE FROM REFERENCE LINE "A" TO REFERENCE LINE "B" = 11,200'

Reference Line 7

TRACY'S POINT

E 356,000

E 357,000

E 358,000

E 359,000

E 360,000

E 361,000

E 362,000

E 363,000

LONG SAULT ISLAND SOUTH CHANNEL

MASSENA WEIR

TO MASSENA CANAL INTAKE CHANNEL

VICINITY OF MASSENA WEIR

SCALE 1" = 400'

NOTE FOR GENERAL LOCATION SEE SHEET NO BD-1-1/1

1ST STEP CONSTRUCTION

CLOSURE CONSTRUCTION 13 - 40 BAYS

2ND STEP CONSTRUCTION

ELEV ABOVE M.S.L.

300

200

100

Estimated Rock Line

Approx Sound Line

PROFILE OF LONG SAULT DAM

100 SCALE 1" = 100' 200 300

TYPE	DATE	REVISION	REV BY	CK BY	APP BY
	11-6-41	Vicinity Massena Weir added, profile of dam made	CHL H		

ST LAWRENCE RIVER PROJECT

LONG SAULT DAM

COFFERDAMS

GENERAL LAYOUT

IN 3 SHEETS SHEET NO 10 SCALE 1" = 400'

400 0 400 800

U.S. ENGINEER OFFICE, MASSENA, NEW YORK NOV 6, 1941

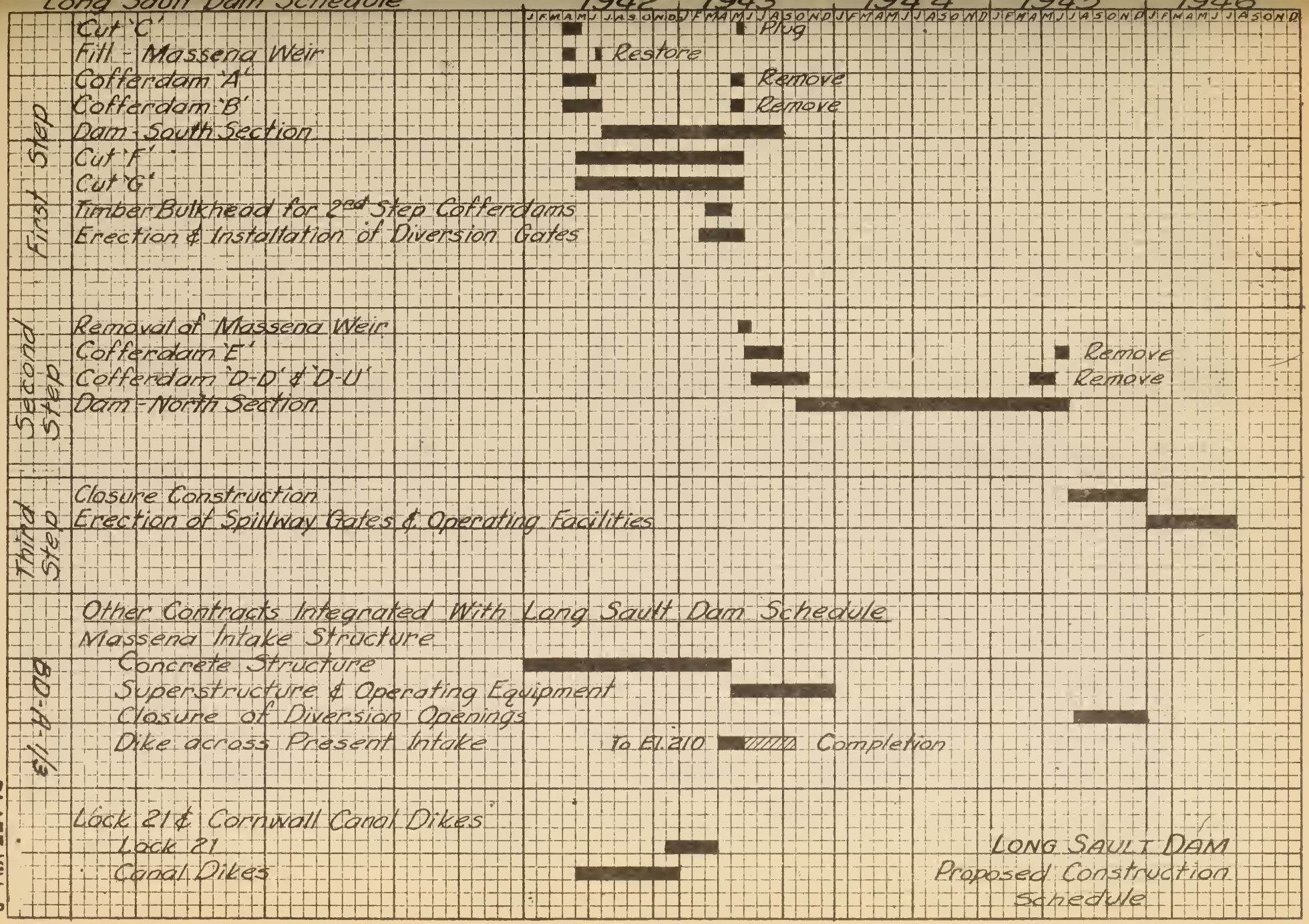
SUBMITTED	RECOMMENDED	APPROVED
Donald Bardwell, ASSOC ENGINEER	[illegible], ASSOC ENGINEER	[illegible], COL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY C.H.L.H. CHECKED BY O.C.B. FILE NO BD-1-5/1

TRANSMITTED WITH LETTER OR ENDORSEMENT DATED 194

PLATE XIV-2

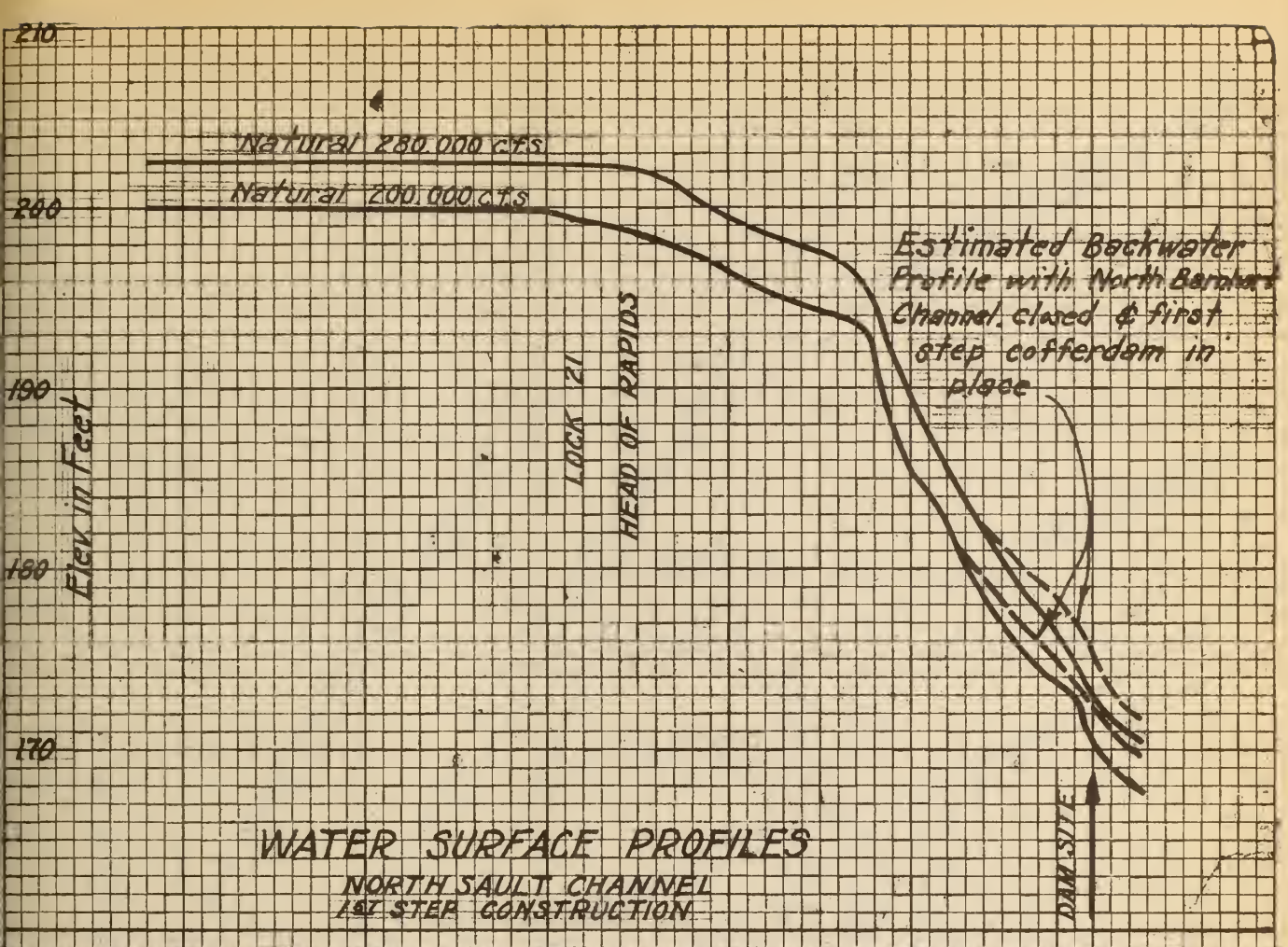
Long Sault Dam Schedule


1942
1943
1944
1945
1946
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
First Step
Cut 'C'
Fill - Massena Weir
Cofferdam 'A'
Cofferdam 'B'
Dam - South Section
Cut 'F'
Cut 'G'
Timber Bulkhead for 2nd Step Cofferdams
Erection & Installation of Diversion Gates
Plug
Restore
Remove
Remove
Second Step
Removal of Massena Weir
Cofferdam 'E'
Cofferdam 'D-D' & 'D-U'
Dam - North Section
Remove
Remove
Third Step
Closure Construction
Erection of Spillway Gates & Operating Facilities
Other Contracts Integrated With Long Sault Dam Schedule
Massena Intake Structure
Concrete Structure
Superstructure & Operating Equipment
Closure of Diversion Openings
Dike across Present Intake
To El. 210
Completion
Lock 21 & Cornwall Canal Dikes
Lock 21
Canal Dikes

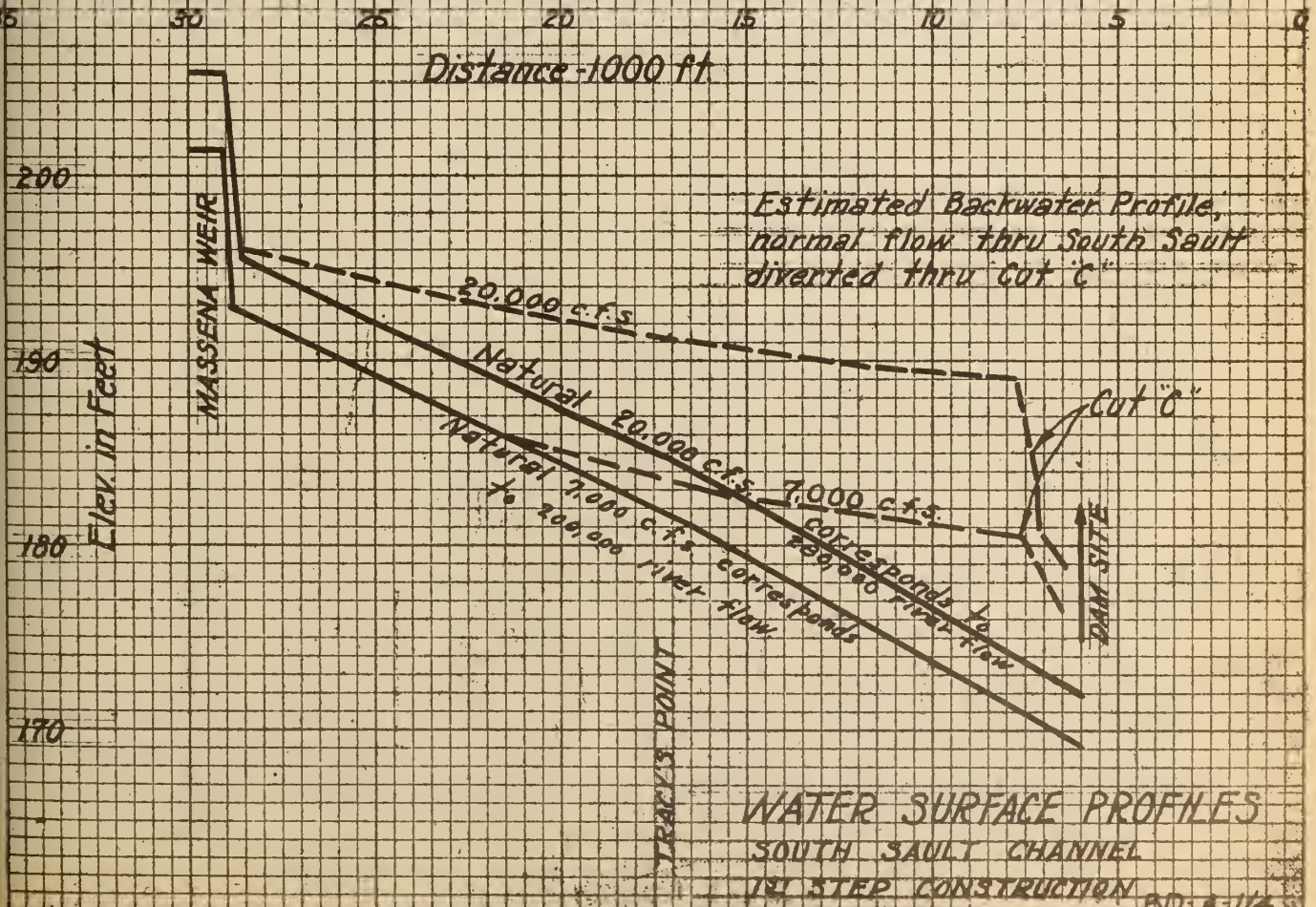
60-4-13

LONG SAULT DAM
Proposed Construction
Schedule

PLATE XIV-3



WATER SURFACE PROFILES
NORTH SAULT CHANNEL
1ST STEP CONSTRUCTION



WATER SURFACE PROFILES
SOUTH SAULT CHANNEL
1ST STEP CONSTRUCTION

BD-A-114

PLATE XIV - 4

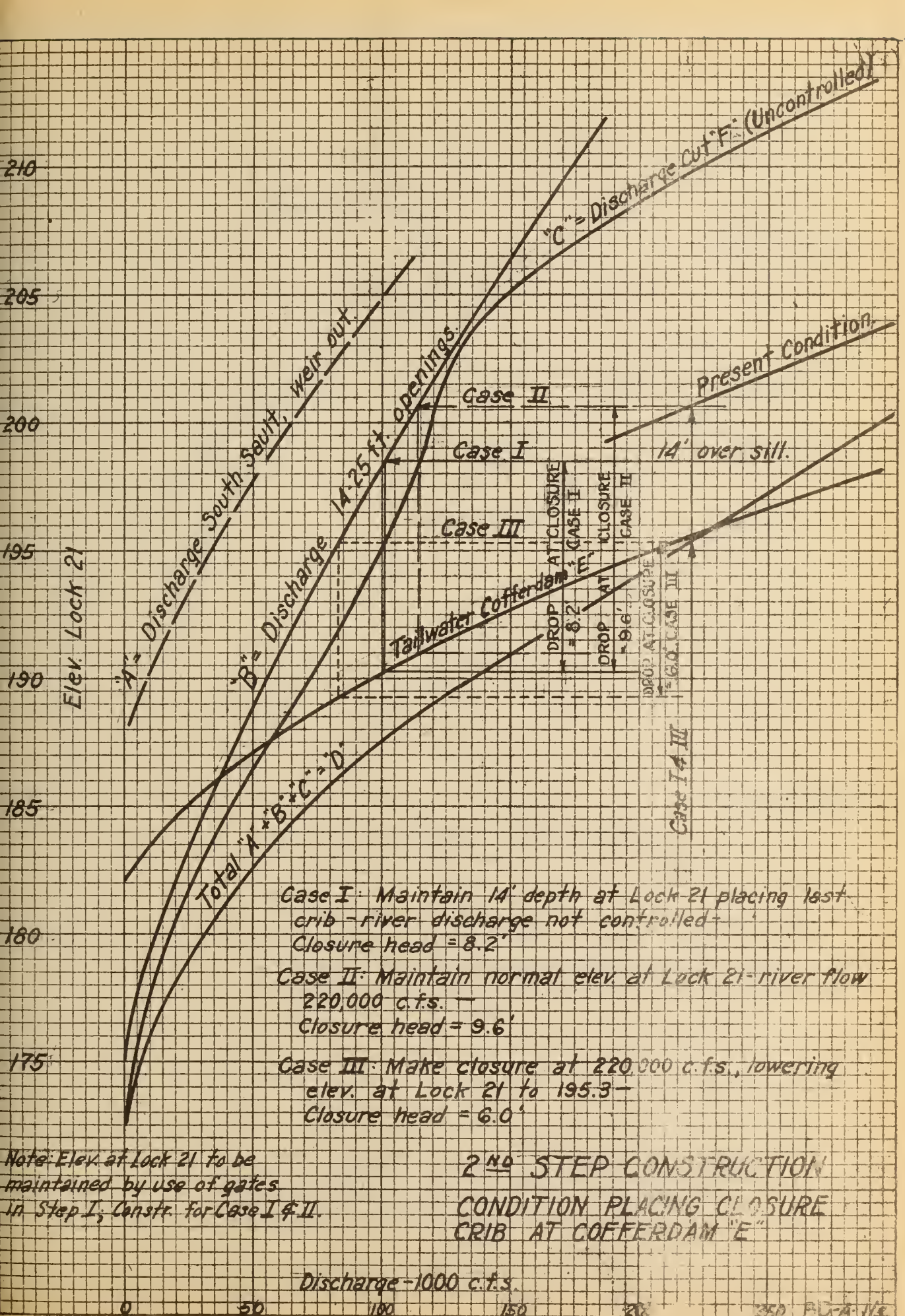
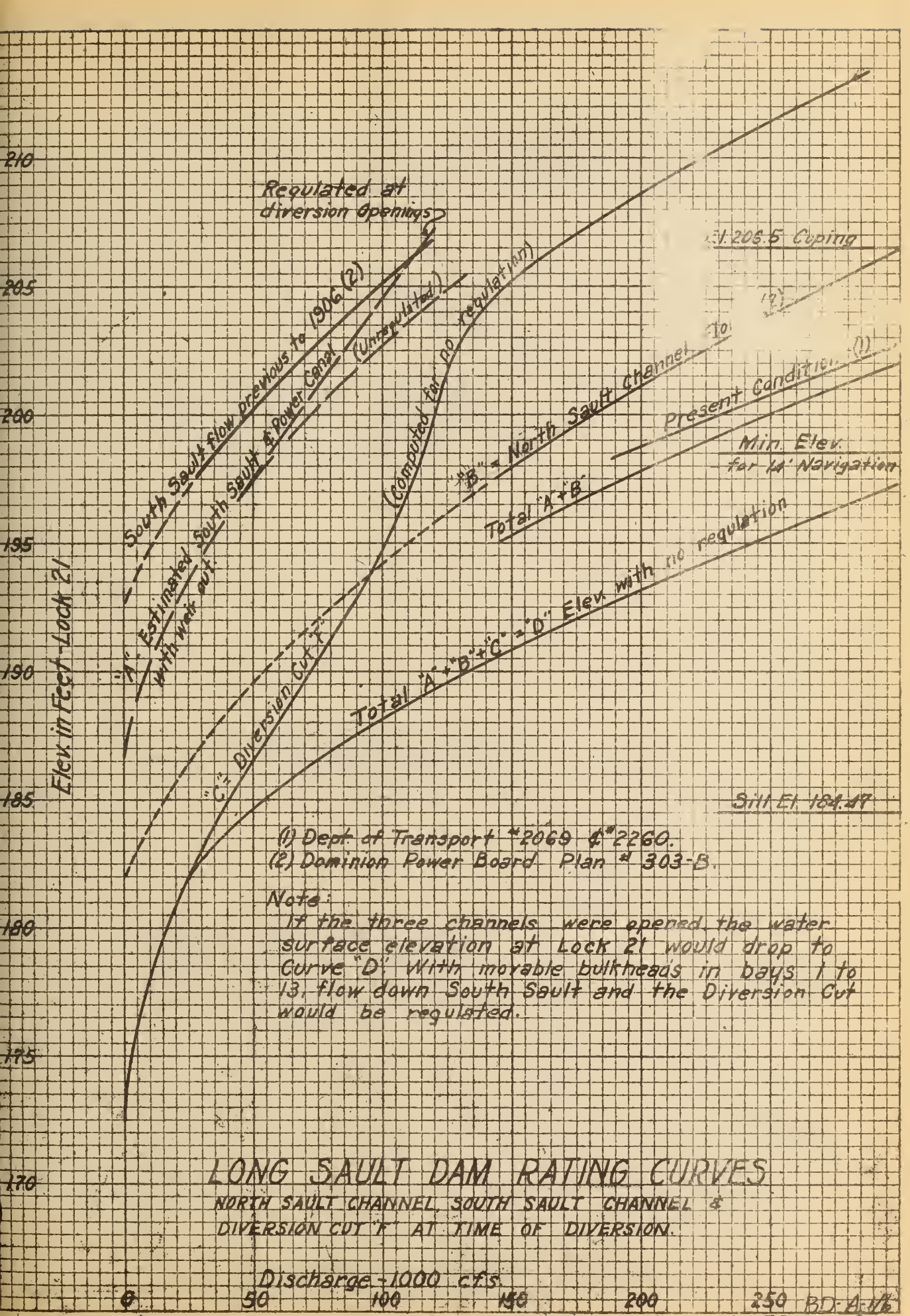
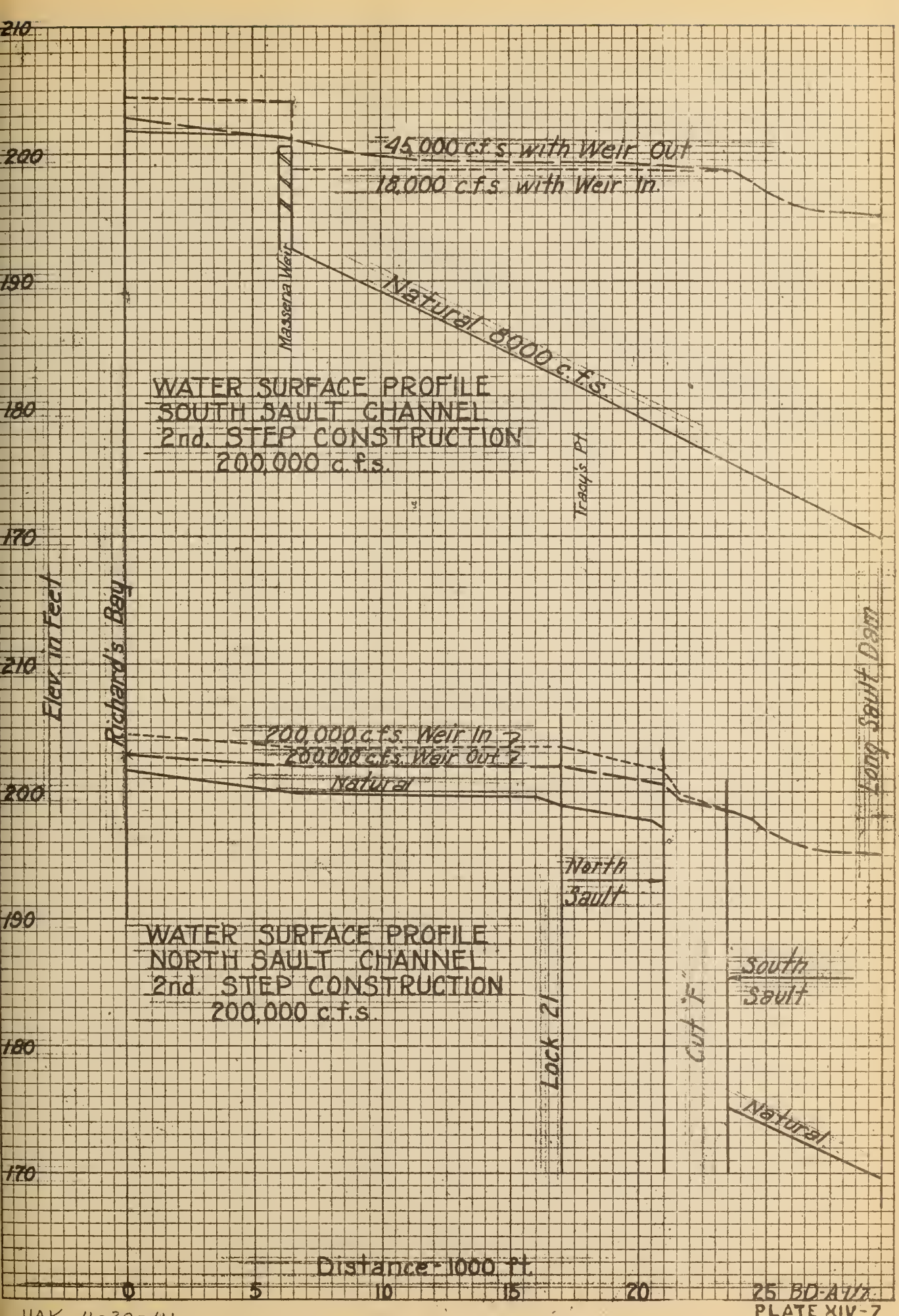

210
205
200
195
190
185
180
175
Elev. Lock 21
"A" = Discharge South Sault, weir out.
"B" = Discharge 14-25 ft. openings
"C" = Discharge Cut "F" (Uncontrolled)
Total "A" + "B" + "C" = "D"
Case II
Case I
Case III
Present Condition
14' over sill.
Tailwater Cofferdam "E"
DROP AT CLOSURE CASE II = 8.2'
DROP AT CLOSURE CASE III = 9.6'
DROP AT CLOSURE CASE III = 6.0'
Case I & III
Case I: Maintain 14' depth at Lock 21 placing last crib - river discharge not controlled - Closure head = 8.2'
Case II: Maintain normal elev. at Lock 21 - river flow 220,000 c.f.s. — Closure head = 9.6'
Case III: Make closure at 220,000 c.f.s., lowering elev. at Lock 21 to 195.3 — Closure head = 6.0'
Note: Elev. at Lock 21 to be maintained by use of gates in Step I, Constr. for Case I & II.
2ND STEP CONSTRUCTION
CONDITION PLACING CLOSURE CRIB AT COFFERDAM "E"
Discharge - 1000 c.f.s.
0
50
100
150
200

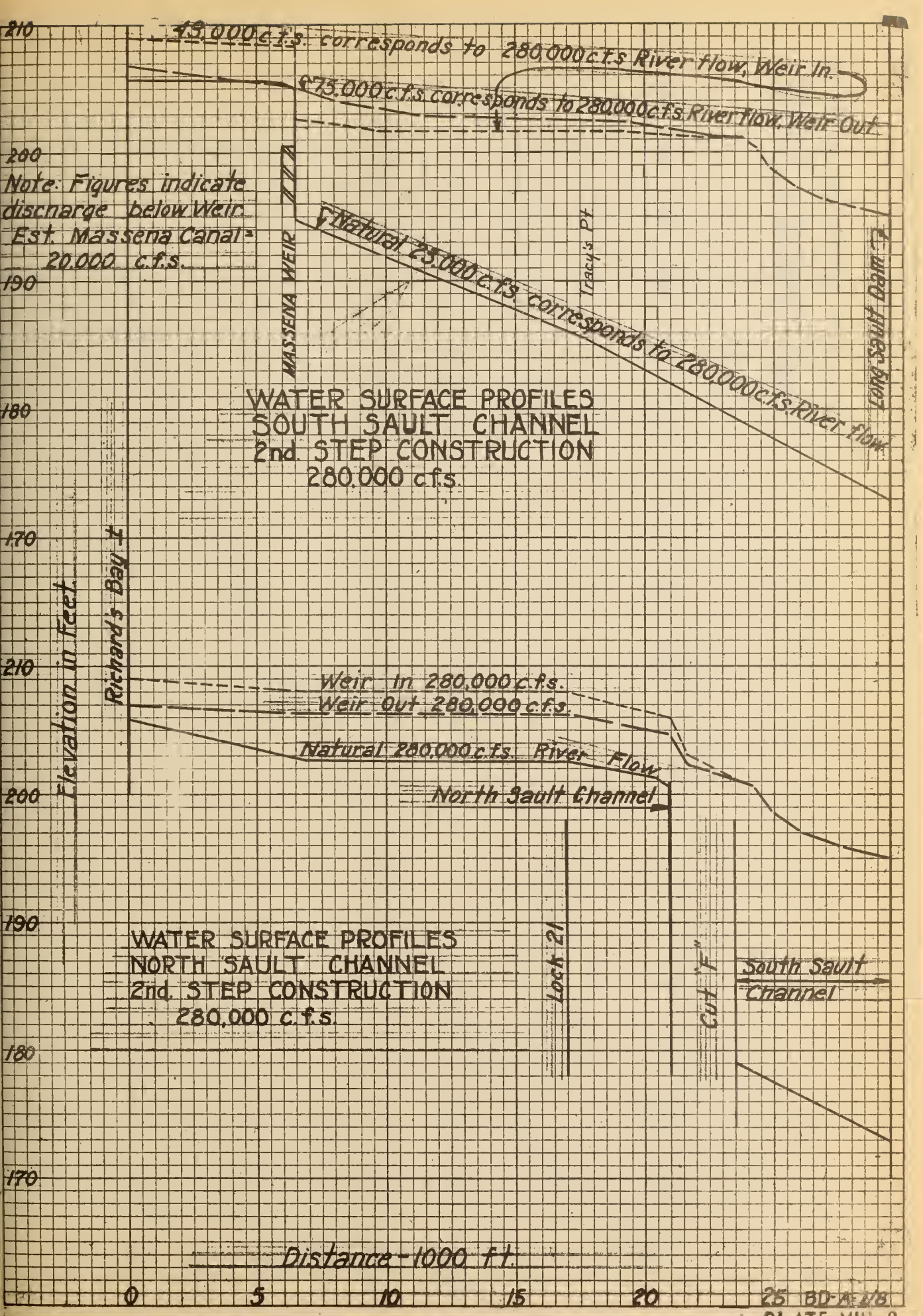
PLATE XIV-5


Regulated at diversion openings
E.V. 206.5 Coping
(2)
(1)
Present Condition
Min. Elev. for 14' Navigation
"B" = North Sault Channel
Total "A"+"B"
(Computed for no regulation)
South Sault flow previous to 1906 (2)
"A" Estimated South Sault & Power Canal (Unregulated) with weir out
"C" Diversion Cut "F"
Total "A"+"B"+"C" = "D" Elev. with no regulation
Sill El. 184.47
Elev. in Feet - Lock 21
210
205
200
195
190
185
180
175
170
(1) Dept. of Transport # 2069 & # 2260.
(2) Dominion Power Board Plan # 303-B.
Note:
If the three channels were opened the water surface elevation at Lock 21 would drop to Curve "D" With movable bulkheads in bays 1 to 13, flow down South Sault and the Diversion Cut would be regulated.
LONG SAULT DAM RATING CURVES
NORTH SAULT CHANNEL, SOUTH SAULT CHANNEL & DIVERSION CUT "F" AT TIME OF DIVERSION.
Discharge - 1000 c.f.s.
0
50
100
150
200
250
B.D.-A-1/6
PLATE XIV - 6



HAK. 4-30-41

BD-A112.
PLATE XIV-7



HAK. 4-30-41

BD-A-1/8

PLATE XIV-8

LONG SAULT DAM

Capacity of Diversion Sluices

PLATE XIV-9

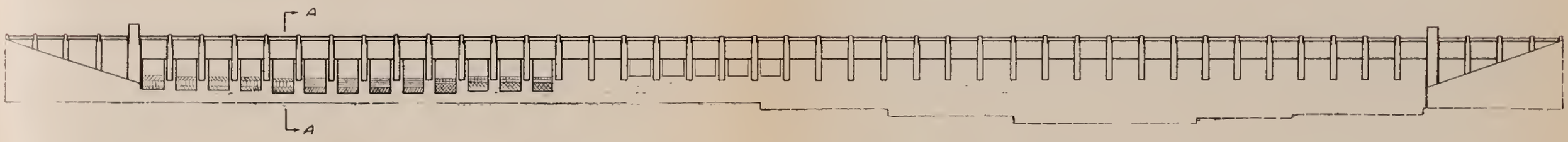
BD-A-7/9

1ST STEP CONSTRUCTION

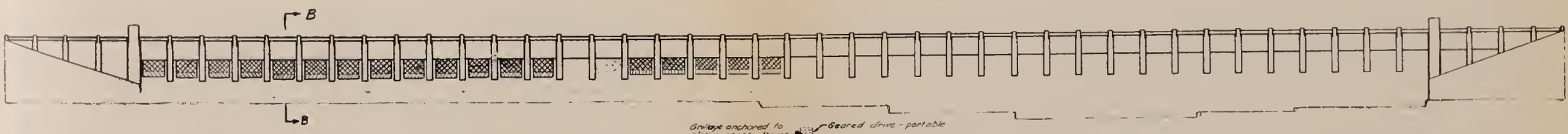
1ST STEP CONSTRUCTION

2ND STEP CONSTRUCTION

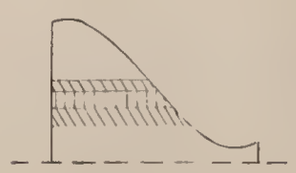
2ND STEP CONSTRUCTION



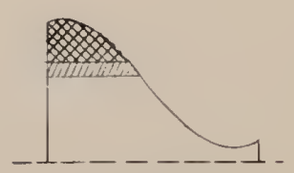
CLOSURE STEP - BEFORE RAISING POOL



CLOSURE STEP - AFTER RAISING POOL



SECTION A-A



SECTION B-B

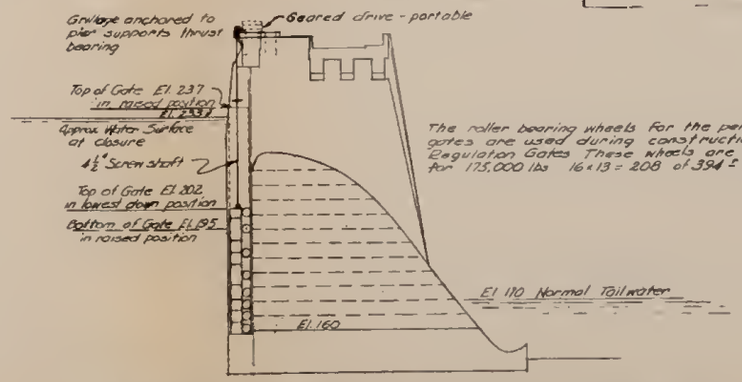

Girlage anchored to pier supports thrust bearing
Geared drive - portable
Top of Gate El 237 in raised position
El 237
Approx Water Surface at closure
4½" Screw shaft
Top of Gate El 202 in lowest down position
Bottom of Gate EL 185 in raised position
The roller bearing wheels for the permanent gates are used during construction for Regulation Gates These wheels are designed for 175,000 lbs 16 x 13 = 208 of 394 ± required
El 110 Normal Tailwater
El 160

DIAGRAM OF PROPOSED REGULATION GATES

ST. LAWRENCE RIVER PROJECT

LONG SAULT DAM
CONSTRUCTION STEPS
PLAN A

IN SHEETS	SHEET NO	SCALE
		0 100 200

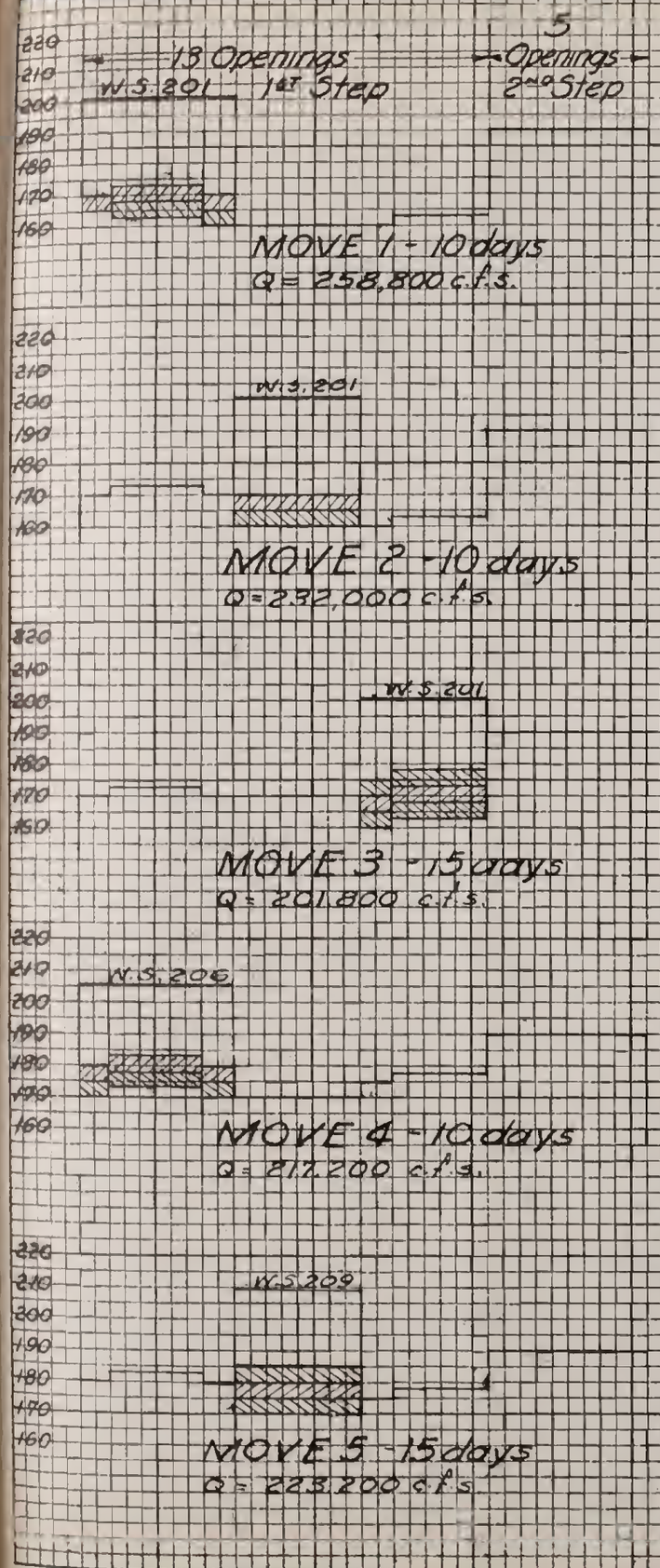
U.S. ENGINEER OFFICE, MASSENA, NEW YORK MARCH 26 1941

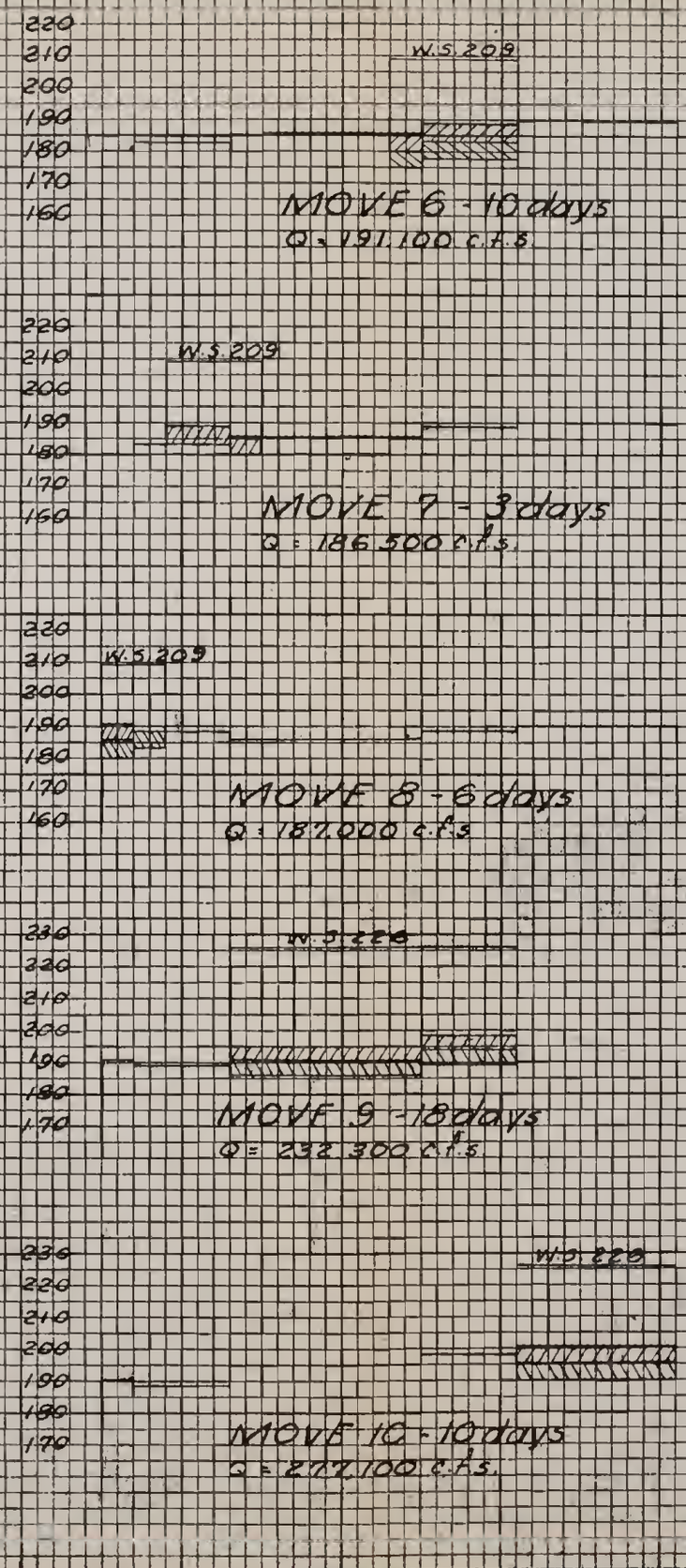
SUBMITTED	RECOMMENDED	APPROVED
D.C. Bondurant ASSOC. ENGINEER	J.D. Hagerman HEAD. ENG. D. Bullard DIV. CORP OF ENGINEERS	A.D. Jones COL. CORP OF ENGINEERS DIST. ENGINEER

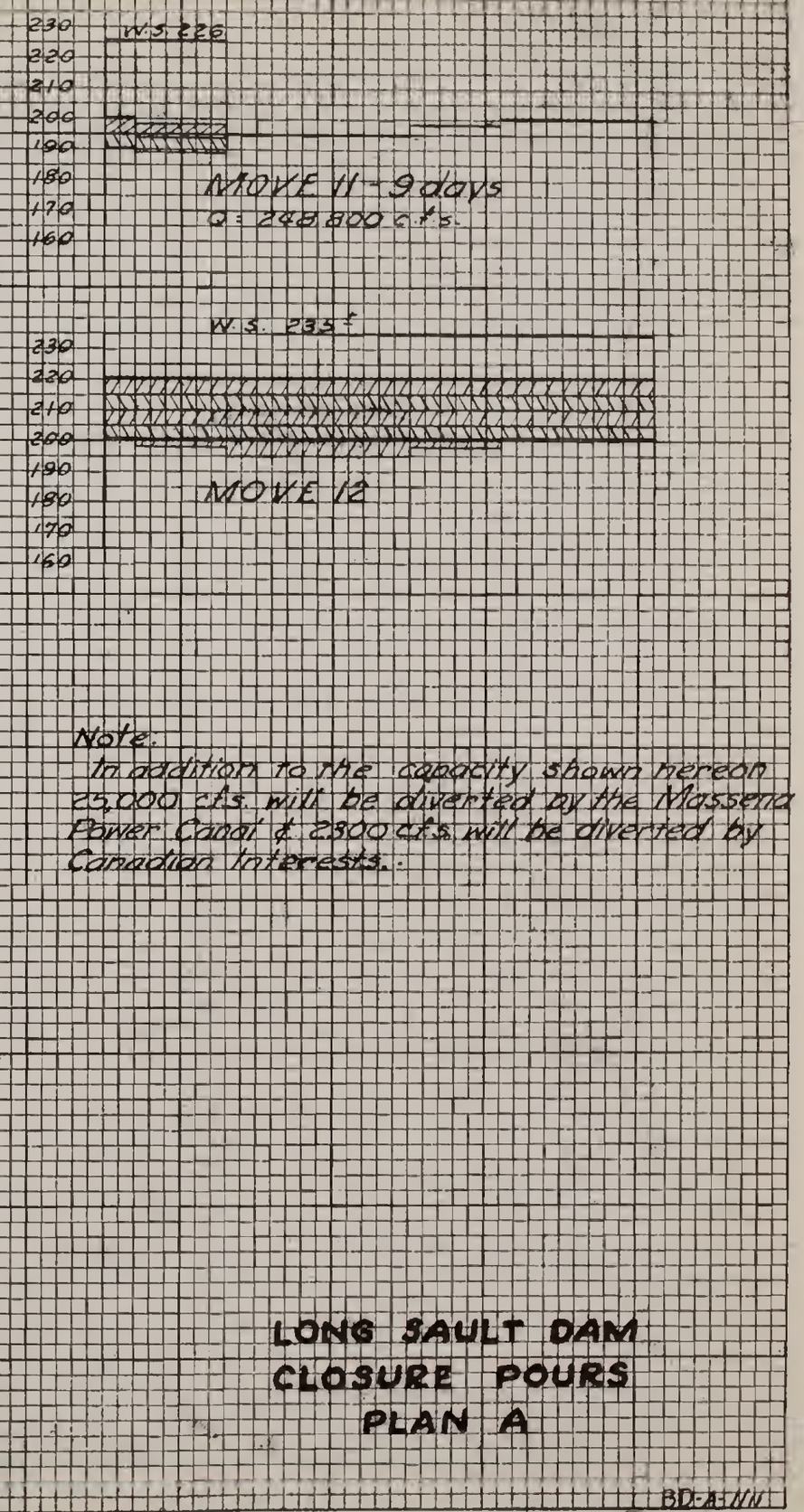
DRAWN BY JJC CHECKED BY: D.C.B. 80-A-1/18

TRANSMITTED WITH LETTER OF ENDORSEMENT DATED

PLATE NO. XIV-10





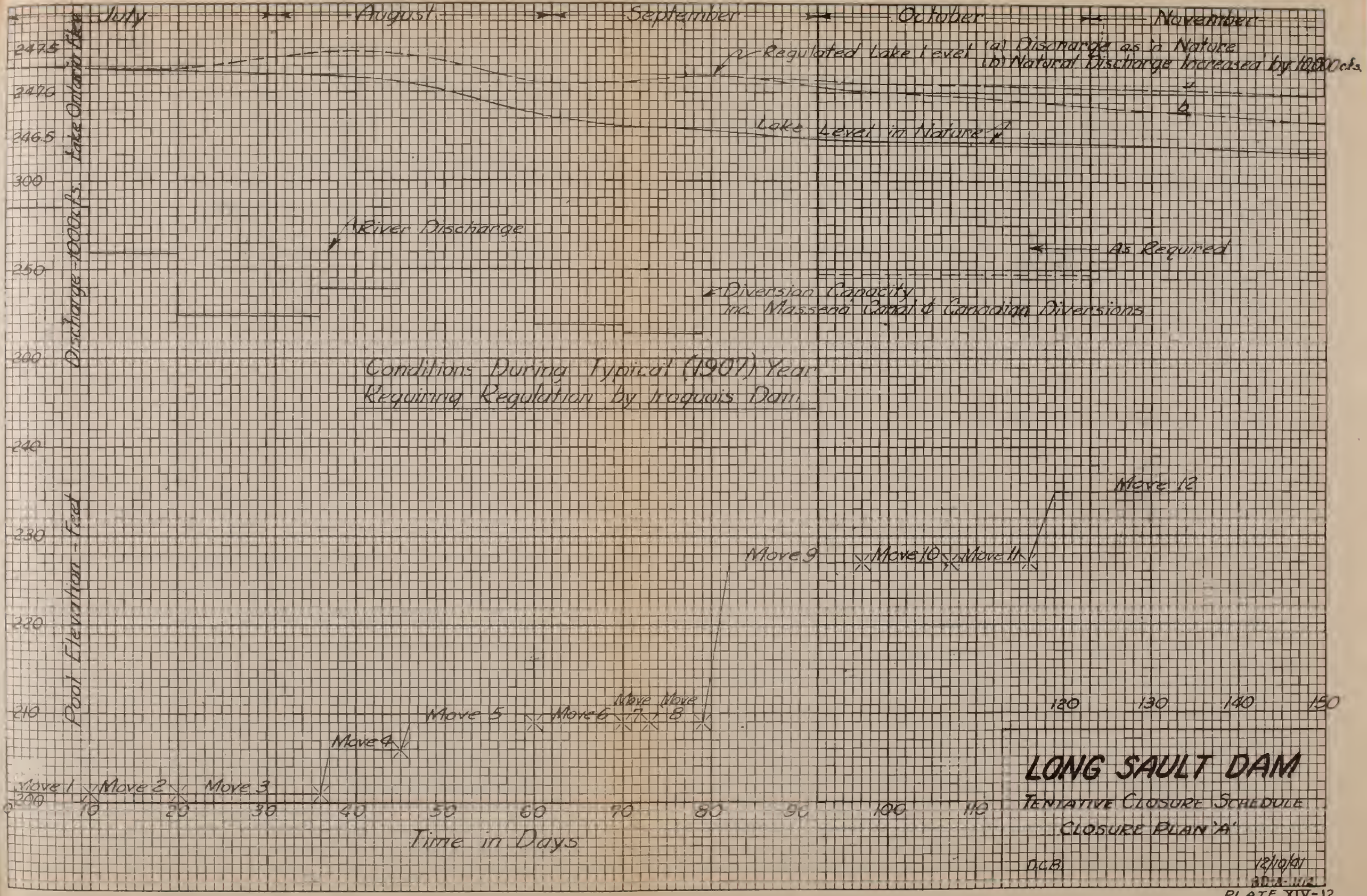


Note:
In addition to the capacity shown hereon 25,000 c.f.s. will be diverted by the Massena Power Canal & 2300 c.f.s. will be diverted by Canadian Interests.

LONG SAULT DAM
CLOSURE POURS
PLAN A

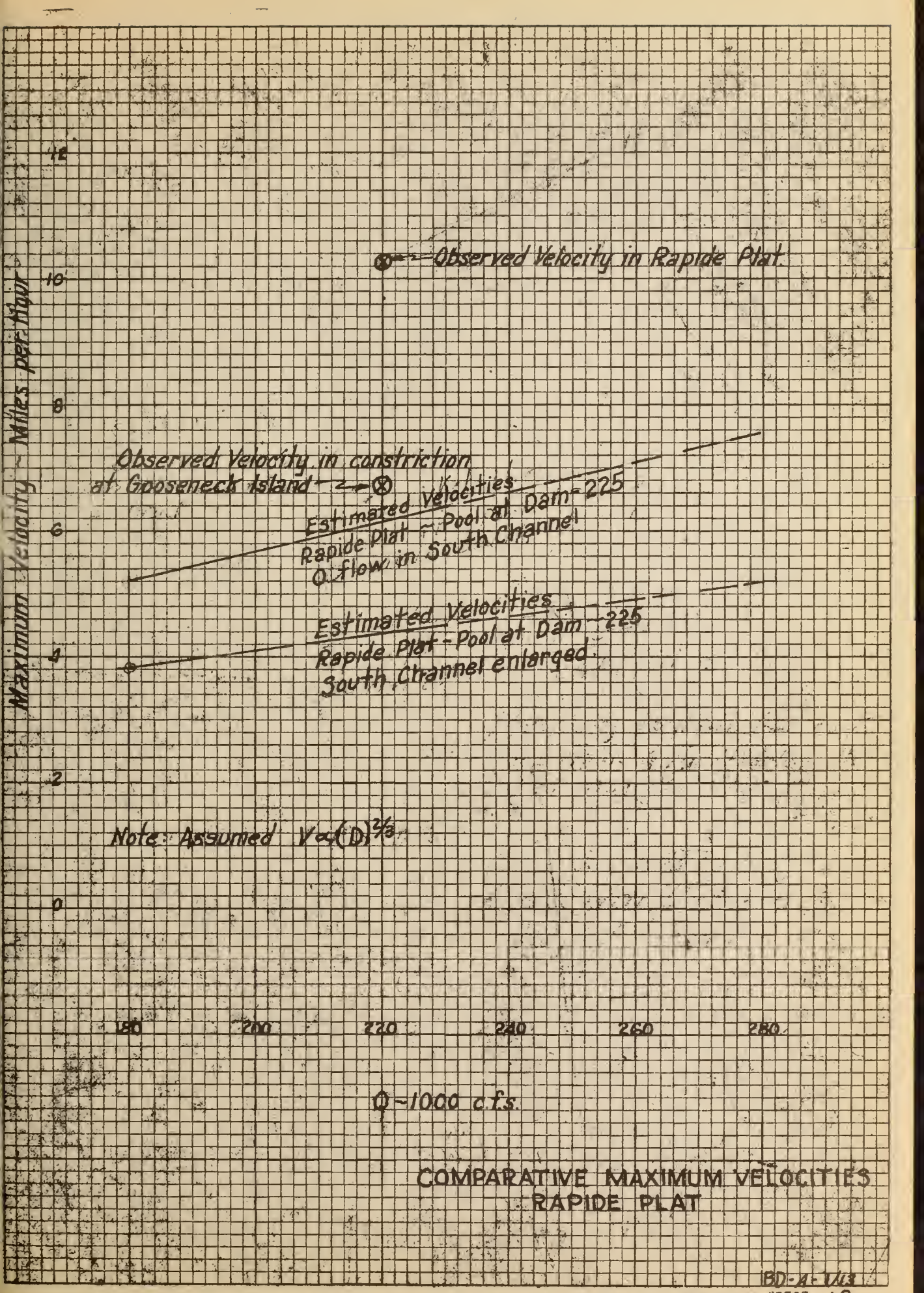
BD-A-NN

PLATE XIV - 11



Conditions During Typical (1907) Year
Requiring Regulation by Iroquois Dam

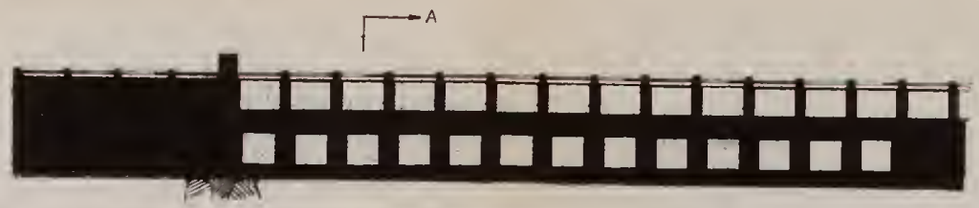
PLATE XIV-12



COMPARATIVE MAXIMUM VELOCITIES
RAPIDE PLAT

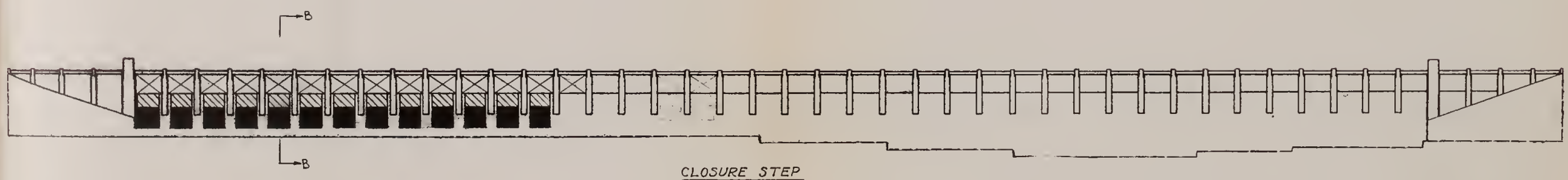
IBD-A-1/13

PLATE XIV -13

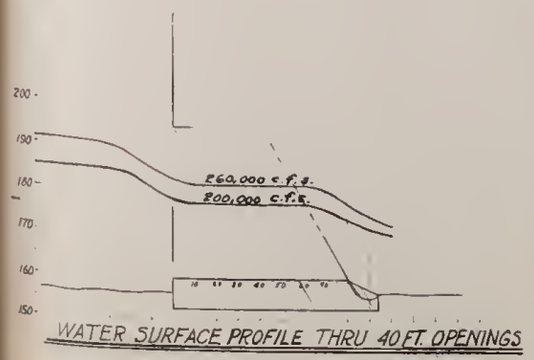


1ST STEP CONSTRUCTION

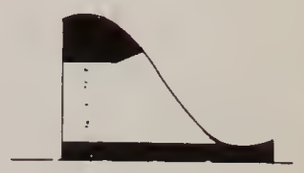
2ND STEP CONSTRUCTION



CLOSURE STEP



WATER SURFACE PROFILE THRU 40 FT. OPENINGS



SECTION A-A

SECTION B-B

ST LAWRENCE RIVER PROJECT

LONG SAULT DAM

CONSTRUCTION STEPS

PLAN - B

IN SHEETS	SHEET NO	SCALE: 1" = 100'

U.S. ENGINEER OFFICE, MASSENA, NEW YORK. MAY 2, 1941

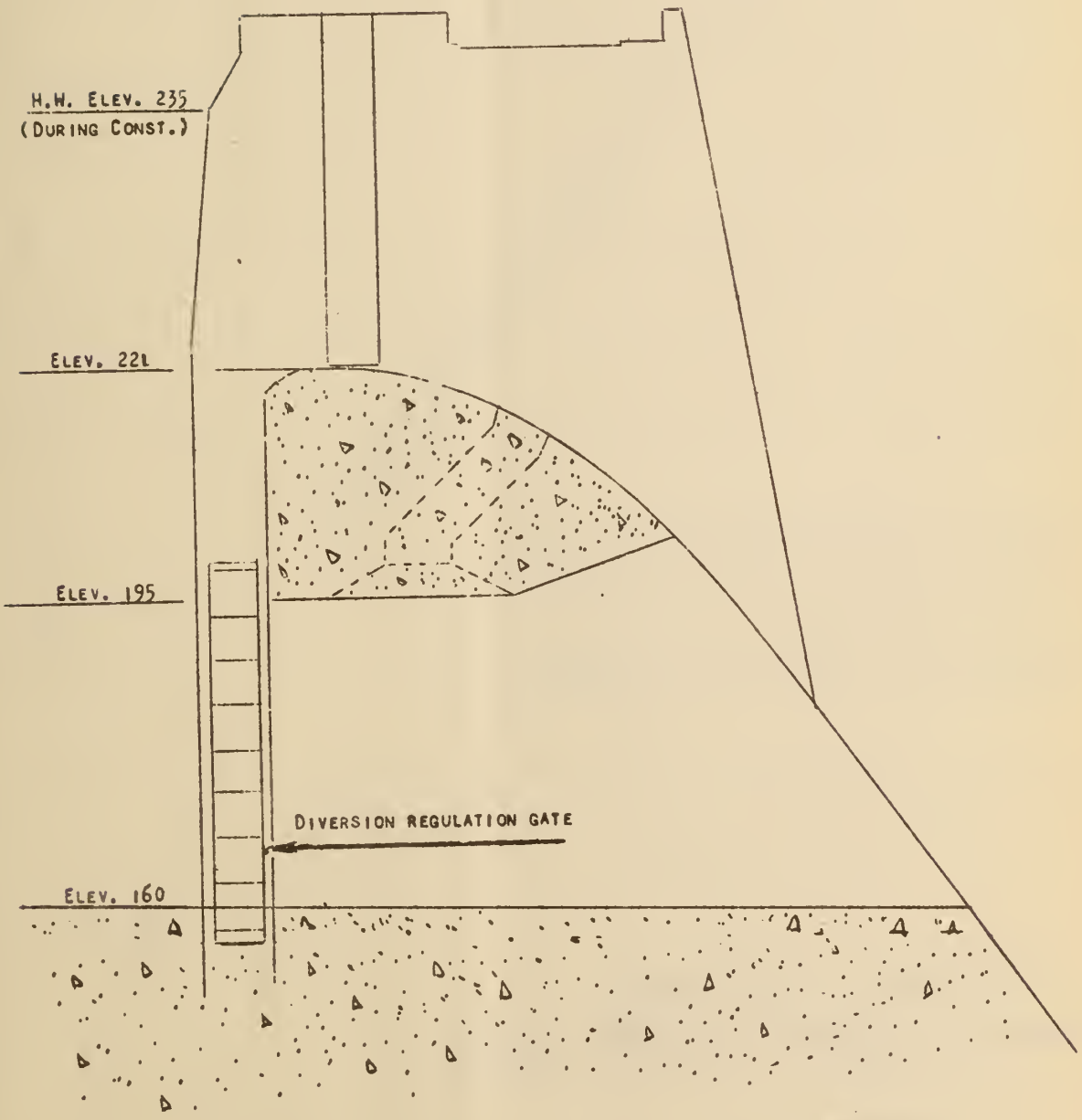
Submitted:	Recommended:	Approved:
D.C. Bondurant, ASSOC. ENGINEER	HEAD ENGR. D. Bullock, LT. COL., C. OF E.	COL., C. OF E. DISTRICT ENGINEER

DR. BY C.H.L-H. CK. BY D.C.B. BD-A-1/19

PLATE XIV-14

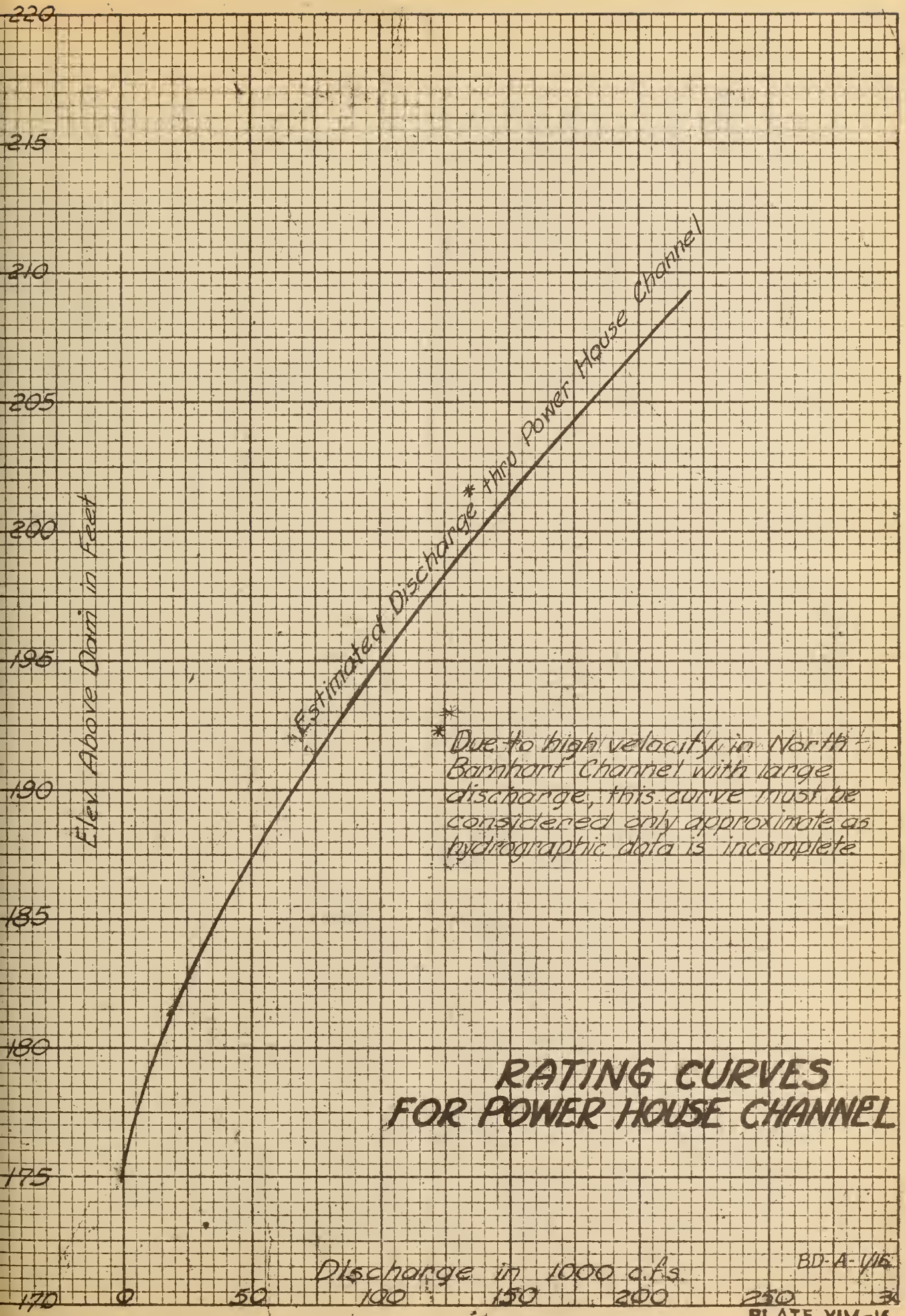
ST. LAWRENCE RIVER PROJECT
LONG SAULT DAM
DIVERSION SLUICES AND REGULATION GATES

SCALE: 1" = 20'



BD-A-1/15

PLATE XIV-15


220
215
210
205
200
195
190
185
180
175
170
Elev Above Dam in Feet
Estimated Discharge* thru Power House Channel
* Due to high velocity in North Barnhart Channel with large discharge, this curve must be considered only approximate as hydrographic data is incomplete.
0
50
100
150
200
250
Discharge in 1000 c.f.s.
RATING CURVES
FOR POWER HOUSE CHANNEL
BD-A-1116
PLATE XIV-16

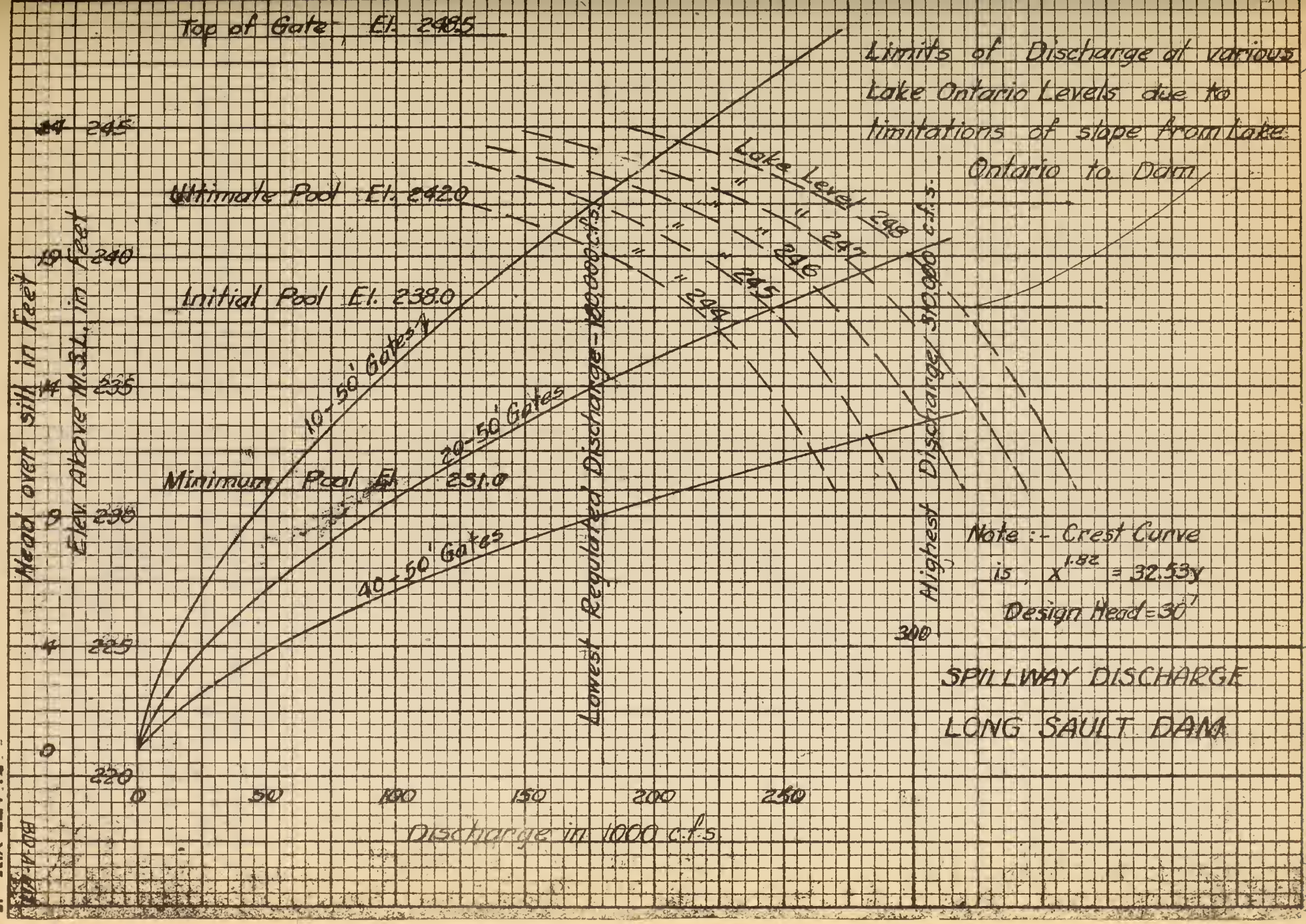
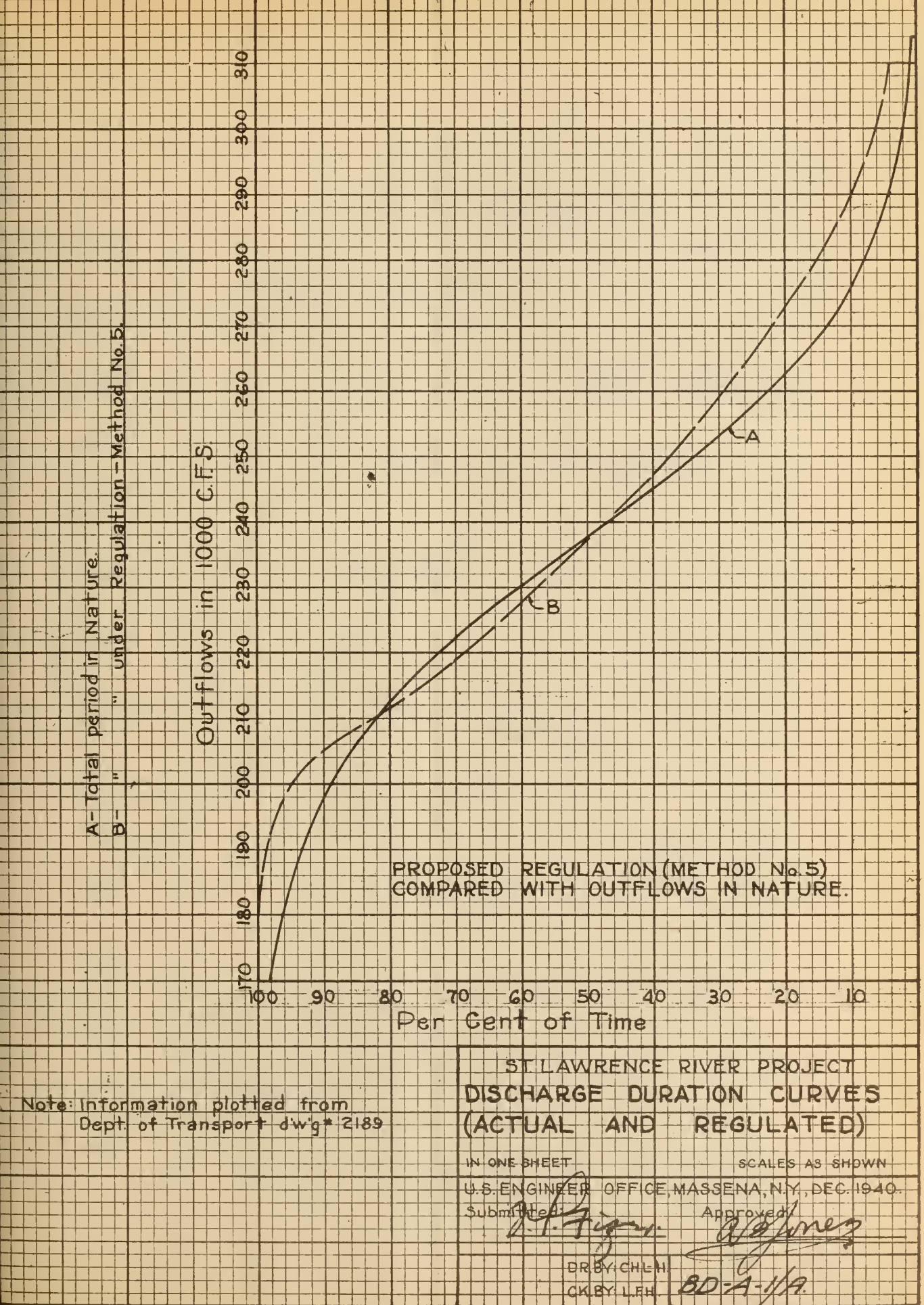

Top of Gate El. 249.5
Limits of Discharge at various Lake Ontario Levels due to limitations of slope from Lake Ontario to Dam
Ultimate Pool El. 242.0
Initial Pool El. 238.0
Minimum Pool El. 231.0
Lake Level 248
" " 247
" " 246
" " 245
" " 244
10-50 Gates
20-50 Gates
40-50 Gates
Lowest Regulated Discharge - 190,000 c.f.s.
Highest Discharge 310,000 c.f.s.
Head over sill in Feet
Elev. above M.S.L. in Feet
Discharge in 1000 c.f.s.
Note :- Crest Curve is $X^{1.82} = 32.53y$
Design Head = 30'
SPILLWAY DISCHARGE
LONG SAULT DAM

PLATE XIV-17



Note: Information plotted from Dept. of Transport d'w'g* 2189

ST. LAWRENCE RIVER PROJECT

DISCHARGE DURATION CURVES (ACTUAL AND REGULATED)

IN ONE SHEET SCALES AS SHOWN

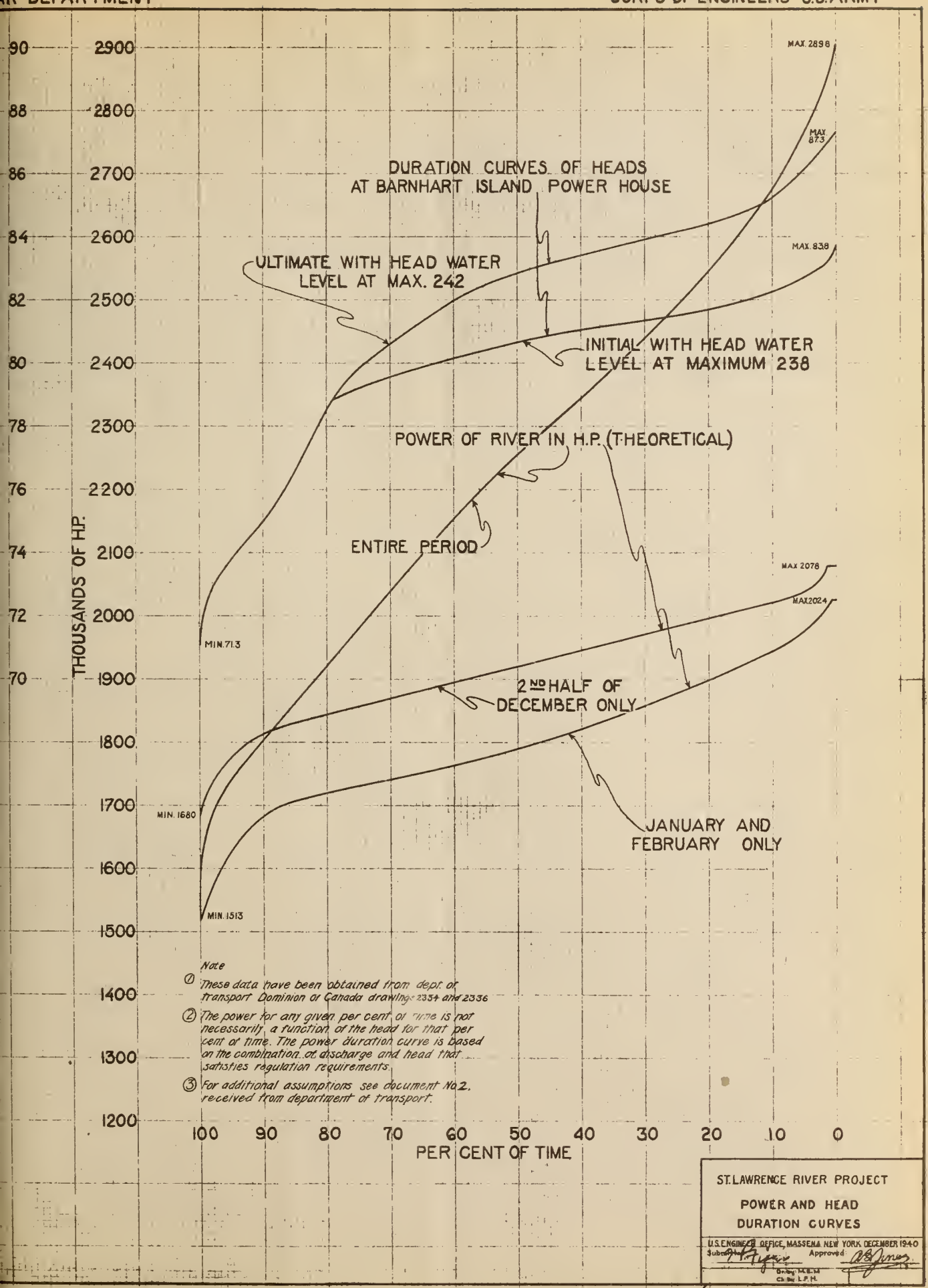
U.S. ENGINEER OFFICE, MASSENA, N.Y., DEC. 1940.

Submitted: A. T. Ferguson Approved: R. A. Jones

DR. BY: CH. E. H.
CK. BY: L. F. H.

80-A-1/9

PLATE XIV-A


DURATION CURVES OF HEADS
AT BARNHART ISLAND POWER HOUSE
ULTIMATE WITH HEAD WATER
LEVEL AT MAX. 242
INITIAL WITH HEAD WATER
LEVEL AT MAXIMUM 238
POWER OF RIVER IN H.P. (THEORETICAL)
ENTIRE PERIOD
2ND HALF OF
DECEMBER ONLY
JANUARY AND
FEBRUARY ONLY
MAX. 2898
MAX 873
MAX. 838
MAX 2078
MAX2024
MIN. 713
MIN. 1680
MIN. 1513
THOUSANDS OF H.P.
PER CENT OF TIME
90 88 86 84 82 80 78 76 74 72 70
2900 2800 2700 2600 2500 2400 2300 2200 2100 2000 1900 1800 1700 1600 1500 1400 1300 1200
100 90 80 70 60 50 40 30 20 10 0

Note

① These data have been obtained from dept. of transport Dominion of Canada drawings 2334 and 2336

② The power for any given per cent of time is not necessarily a function of the head for that per cent of time. The power duration curve is based on the combination of discharge and head that satisfies regulation requirements.

③ For additional assumptions see document No 2. received from department of transport.

ST. LAWRENCE RIVER PROJECT

POWER AND HEAD
DURATION CURVES

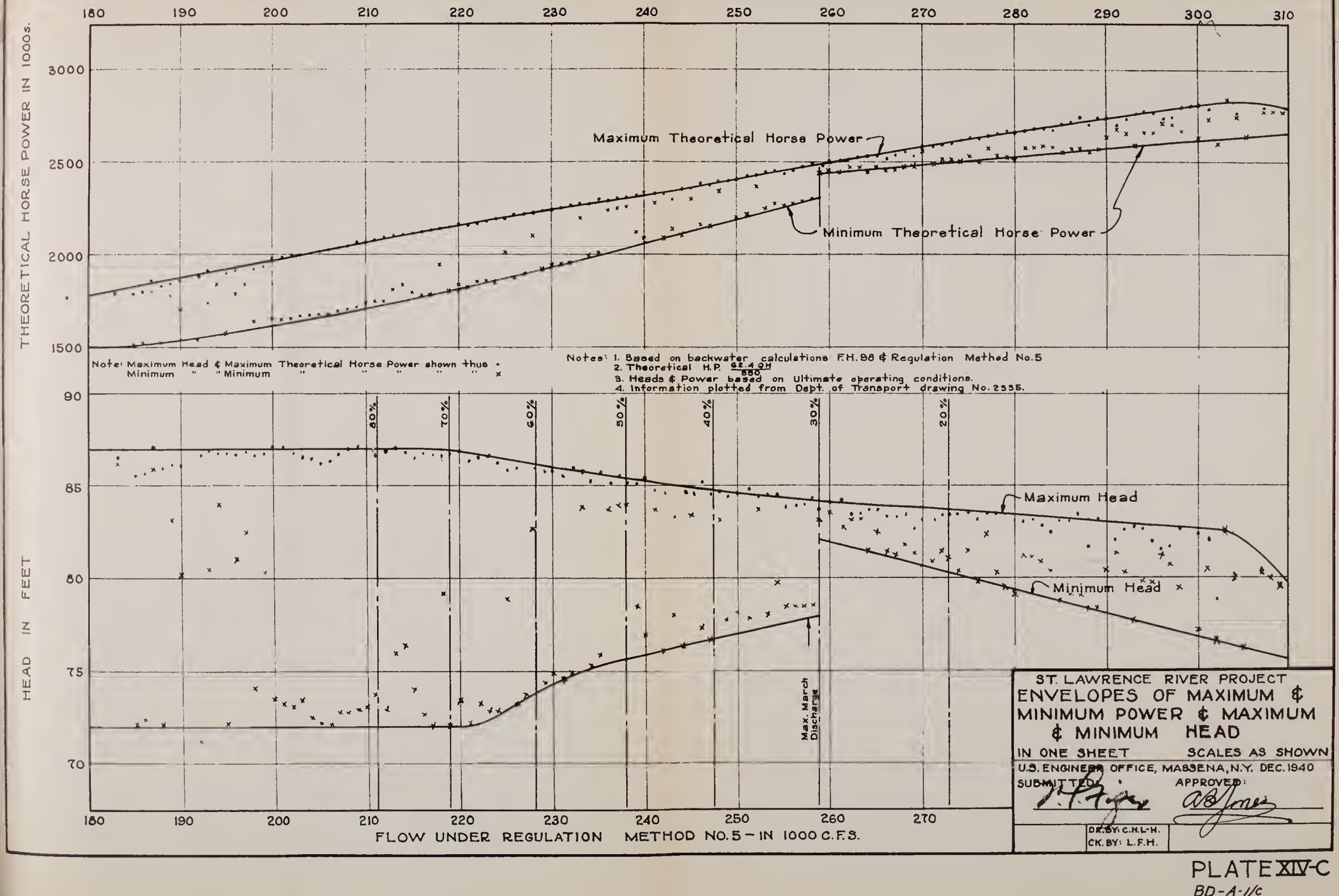
U.S. ENGINEER OFFICE, MASSENA NEW YORK. DECEMBER 1940

Submitted: A. Bryce Approved: A B Jones

Dr. by M.E.M
Ch. by L.F.H.

BD-A-1/8

PLATE XIV B


THEORETICAL HORSE POWER IN 1000s.
180 190 200 210 220 230 240 250 260 270 280 290 300 310
3000
2500
2000
1500
Maximum Theoretical Horse Power
Minimum Theoretical Horse Power
Note: Maximum Head & Maximum Theoretical Horse Power shown thus •
Minimum " " Minimum " " " " " " " x
Notes: 1. Based on backwater calculations F.H. 98 & Regulation Method No.5
2. Theoretical H.P. 62.4 QH / 550
3. Heads & Power based on Ultimate operating conditions.
4. Information plotted from Dept. of Transport drawing No. 2335.
90
85
80
75
70
80%
70%
60%
50%
40%
30%
20%
Maximum Head
Minimum Head
Max. March Discharge
HEAD IN FEET
180 190 200 210 220 230 240 250 260 270
FLOW UNDER REGULATION METHOD NO. 5 — IN 1000 C.F.S.

ST. LAWRENCE RIVER PROJECT

ENVELOPES OF MAXIMUM & MINIMUM POWER & MAXIMUM & MINIMUM HEAD

IN ONE SHEET SCALES AS SHOWN

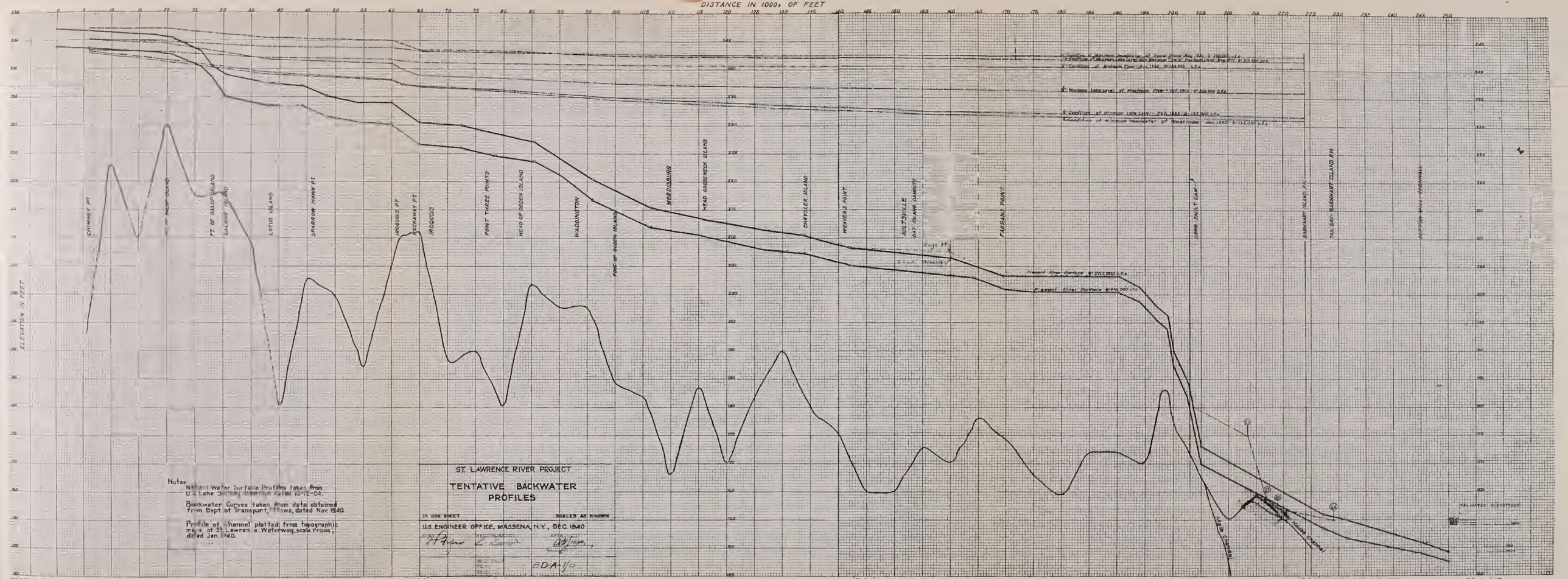
U.S. ENGINEER OFFICE, MASSENA, N.Y. DEC. 1940

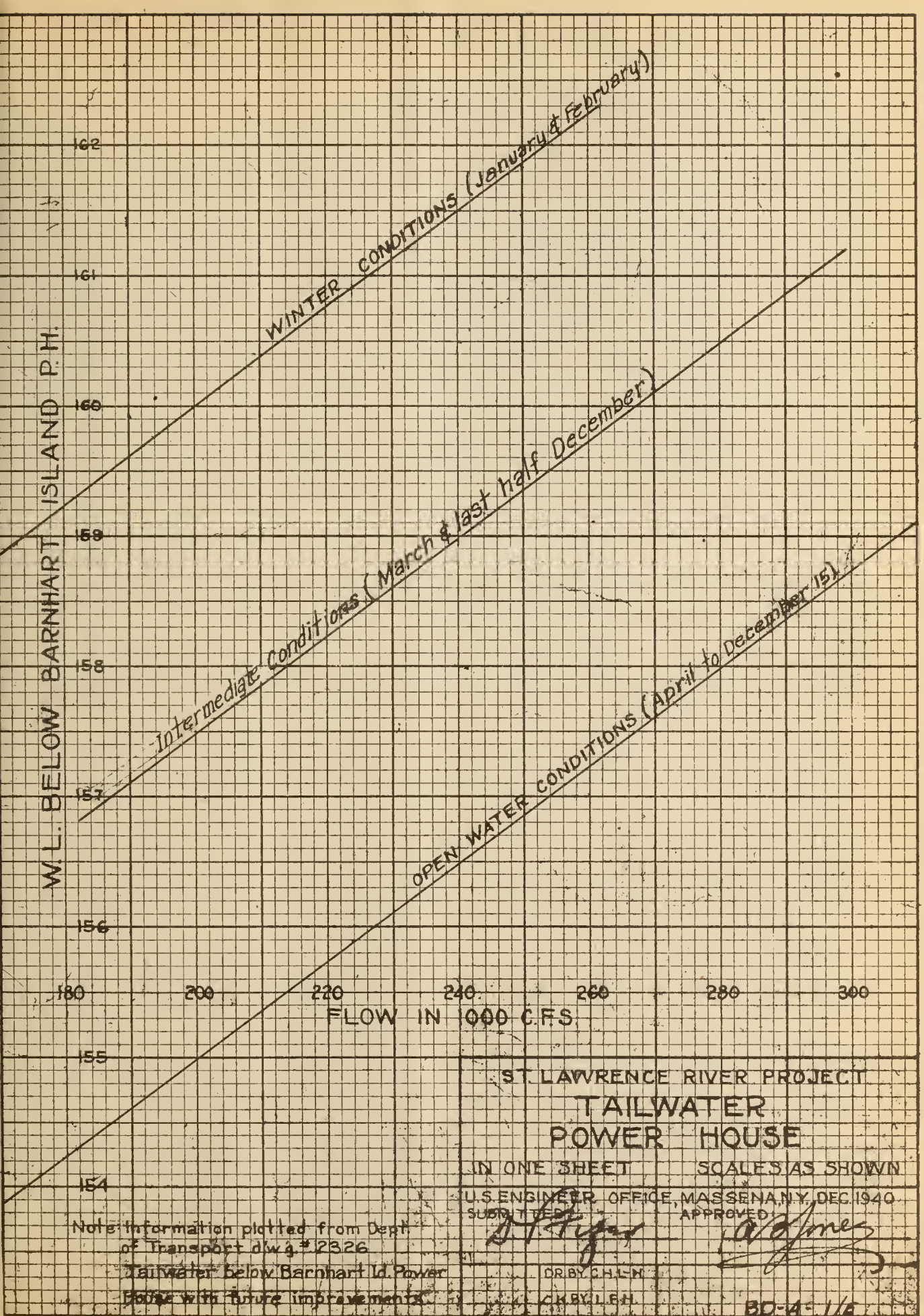
SUBMITTED: APPROVED:

DR. BY: C.H.L-H.
CK. BY: L.F.H.

PLATE XIV-C

BD-A-11c


DISTANCE IN 1000s OF FEET
ELEVATION IN FEET
CHIMNEY PT
MEAD ISLAND
PT. OF GALOP ISLAND
LALONE ISLAND
LOTUS ISLAND
SPARROW HAWK PT
IROQUOIS PT
ROCKAWAY PT
IROQUOIS
POINT THREE POINTS
HEAD OF DEER ISLAND
WADDINGTON
POINT OF DEER ISLAND
MORRISBURG
HEAD GOSSENECK ISLAND
CHRYSLER ISLAND
WERNER'S POINT
ADOLPHUSVILLE
SAT. ISLAND DAM SITE
FARRANS POINT
LONG SAULT DAM
BARNHART ISLAND PT.
TAIL BAY BARNHART ISLAND PT.
CROSSMON MILLS - DOWNWARD
Present River Surface @ 240,000 c.f.s.
Present River Surface @ 200,000 c.f.s.
MAIN CHANNEL
WELLAND CANAL
TAILWATER ELEVATIONS
Notes
Natural Water Surface Profiles taken from U.S. Lake Survey Charts dated 10-12-24.
Backwater Curves taken from data obtained from Dept. of Transport, Ottawa, dated Nov. 1940.
Profile of channel plotted from topographic maps of St Lawrence Waterway, scale 1"=1000', dated Jan. 1940.
ST. LAWRENCE RIVER PROJECT
TENTATIVE BACKWATER PROFILES
IN ONE SHEET
SCALES AS SHOWN
U.S. ENGINEER OFFICE, MASSENA, N.Y., DEC. 1940
BDA-1/0
PLATE XIV - D
BD A 1/D
PLATE XIV-D



ST. LAWRENCE RIVER PROJECT

TAILWATER POWER HOUSE

IN ONE SHEET SCALES AS SHOWN

U.S. ENGINEER OFFICE, MASSENA, N.Y. DEC. 1940

SUBMITTED: D. F. Tyler APPROVED: [illegible]

DR. BY C.H.L-H

CK. BY L.E.H.

BD-4-1/2

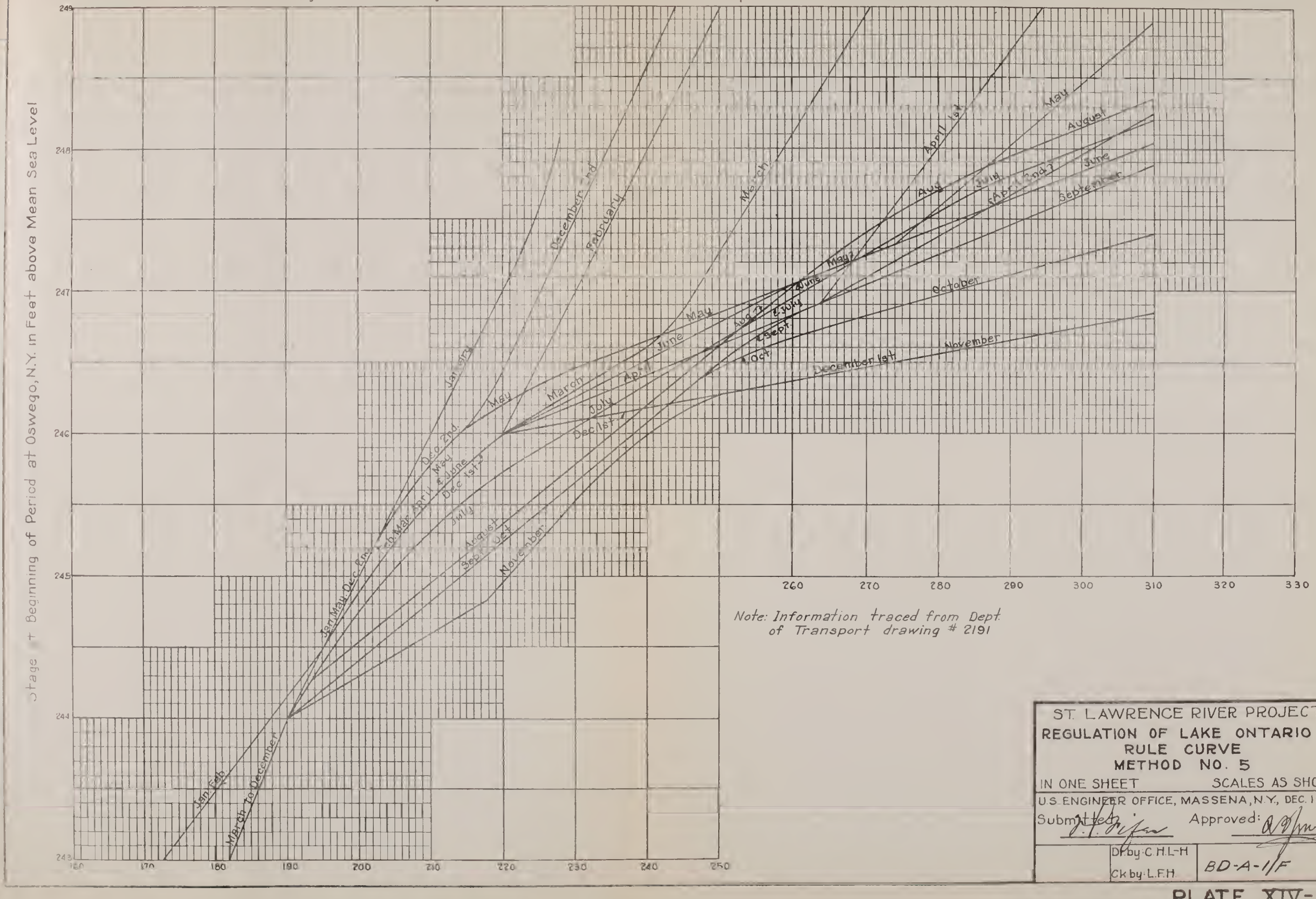
Note: Information plotted from Dept. of Transport dwg. #2326 Tailwater below Barnhart Id. Power House with future improvements.

PLATE XIV-E

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY

Regulated Discharge of the St. Lawrence River for the period in Thousands of Second Feet



Note: Information traced from Dept. of Transport drawing # 2191

ST. LAWRENCE RIVER PROJECT

REGULATION OF LAKE ONTARIO
RULE CURVE
METHOD NO. 5

IN ONE SHEET SCALES AS SHOWN

U.S. ENGINEER OFFICE, MASSENA, N.Y., DEC. 1940

Submitted: L.F. Jackson Approved: A.D. Jones

Dr. by: C.H.L-H
Ck by: L.F.H.

BD-A-1/F

PLATE XIV-F

PART TWO

LONG SAULT DAM

ESTIMATE OF COST

LONG SAULT DAM

Estimate of Cost - March 18, 1942

SUMMARY

1.	General Contract	$8,857,975
2.	Materials & Equipment	7,712,485
		$16,570,460
3.	Engineering & Contingencies 18%-	2,982,540
	Total Cost	$19,553,000

LONG SAULT DAM

Estimate of Cost - March 18, 1942

Bid Items

Item No.	Designation	Unit	Quantity	Unit Price $	Amount $
1	Excavation; Crib Footing	Cu.Yd.	65,900	2.50	164,750
2	Timber Cribs	M.B.M.	5,200	100.00	520,000
3	Crib Sheathing (Bulkhead)	Sq.Ft.	13,800	.75	10,350
4	Steel Sheet Piling	" "	44,200	1.50	66,300
5	Crib Fill	Cu.Yd.	118,200	1.50	177,300
6	Earth Fill; Cofferdams	" "	310,000	.50	155,000
7	Rock Fill; Cofferdams	" "	26,500	2.50	66,250
8	Riprap; Cofferdams	" "	15,700	2.00	31,400
9	Derrick Stone; Cofferdams	Ton	5,000	5.00	25,000
10	Cofferdam Removal	Cu.Yd.	376,800	.50	188,400
11	Unwatering Cofferdams	AcreFt	56,000	6.00	336,000
12	Excavation; Diversion Cuts, Earth	Cu.Yd.	3,310,000	.35	1,158,500
13	Excavation; Diversion Cuts, Rock	" "	5,000	2.00	10,000
14	Fill; Massena Weir, Rock	" "	6,500	5.00	32,500
15	Excavation; Massena Weir	" "	35,000	5.00	175,000
16	Stoplogs; Concrete	" "	1,180	30.00	35,400
17	Diversion Gates; Operation and Maintenance	Sum	Job		300,000
18	Excavation; Common	Cu.Yd.	490,000	.50	245,000
19	Excavation; Rock	" "	80,000	2.00	160,000
20	Excavation; Borrow	" "	180,000	.30	54,000
21	Line Drilling	Sq.Ft.	45,000	1.00	45,000

Item No.	Designation	Unit	Quantity	Unit Price $.	Amount $
22	Drilling 3" Exploratory Holes	Lin.Ft.	17,400	5.00	87,000
23	Drilling 6" Holes	" "	7,500	10.00	75,000
24	Drilling 6" Concrete Cores	" "	1,000	10.00	10,000
25	Drilling Foundation Grout Holes In Rock	" "	64,000	5.00	320,000
26	Drilling Foundation Grout Holes in Concrete	" "	5,000	2.50	12,500
27	Pressure Grouting	Cu.Ft.	40,000	1.00	40,000
28	Core Boxes	Each	930	2.00	1,860
29	Excavation; Railroad & Highway	Cu.Yd.	130,000	.50	65,000
30	Fill; Railroad & Highway	" "	175,000	.12	21,000
31	Earth Fill; Compacted	" "	280,000	.12	33,600
32	Additional Compaction	Square (100sf)	100,000	.02	2,000
33	Filter	Cu.Yd.	16,700	2.00	33,400
34	Riprap, Dumped; Class A	" "	12,400	3.00	37,200
35	Riprap, Dumped; Class B	" "	22,400	2.50	56,000
36	Sand & Gravel Backing	" "	6,600	1.75	11,550
37	Road Surfacing	Sq.Yd.	66,000	.27	17,820
38	Seeded Top Soil	Acre	6	500.00	3,000
39	Seeding	"	4	250.00	1,000
40	Concrete; Class A	Cu.Yd.	17,500	10.00	175,000
41	Concrete; Class B	" "	41,000	6.00	246,000
42	Concrete; Class C	" "	525,000	5.00	2,625,000
43	Rock Flour in Grout	Cu.Ft.	2,000	.50	1,000
44	Sand in Grout	" "	2,000	.25	500
45	Drains; Porous Concrete	Lin.Ft.	31,300	1.00	31,300
46	Special Bituminous Filler, Type C	Cu.Ft.	1,700	1.50	2,550

Item No.	Designation	Unit	Quantity	Unit Price $	Amount $
47	Steel Erection; Structural	Lb.	7,500,000	.03	225,000
48	Steel Erection; Concrete Reinforcing	"	5,000,000	.025	125,000
49	Steel Rails; Placing	"	781,000	.015	11,715
50	Spillway Gates; Erection	"	14,605,000	.02	292,100
51	Gantry Cranes & Fixed Hoists; Erection	Sum	Job		50,000
52	Steel Forgings; Miscellaneous	Lb.	2,500	.30	750
53	Steel, Structural; Miscellaneous	"	5,000	.18	900
54	Iron; Cast	"	40,000	.16	6,400
55	Pipe; Cast Iron	"	38,000	.15	5,700
56	Pipe; Wrought Iron	"	37,000	.25	9,250
57	Pipe; Black Steel, 8"	"	65,300	.15	9,795
58	Pipe; Black Steel, Miscellaneous	"	2,000	.15	300
59	Pipe; Concrete, Halved	Lin.Ft.	5,600	.20	1,120
60	Culverts; 24"	" "	575	4.50	2,588
61	Culverts; 36"	" "	600	7.00	4,200
62	Babbitt	Lb.	46,000	.50	23,000
63	Bronze; Castings	"	3,400	1.00	3,400
64	Copper; Sheet	"	930	.40	372
65	Corrugated Iron; Water Stop	"	73,000	.15	10,950
66	Doors & Windows; Steel	"	4,600	.20	920
67	Highway Guard Rail	Lin.Ft.	29,000	1.25	36,250
68	Handrailing; Steel Pipe 2"	" "	6,300	3.00	18,900
69	Handrailing; Steel Pipe 1-1/2"	" "	600	2.50	1,500
70	Floor Grating; Steel	Lb.	55,000	.15	8,250
71	Safety Treads	"	8,300	.20	1,660

Item No.	Designation	Unit	Quantity	Price $	Amount $
72	Scuttles	Each	2	50.00	100
73	Roof Ventilators	"	6	50.00	300
74	Flag Pole	"	6	200.00	1,200
75	Glass Brick	Sq.Ft.	440	2.00	880
76	Conduit; Metal	Lb.	30,000	.25	7,500
77	Electrical Grounding System	Sum.	Job		1,200
78	Bubbler Pipes	Each	120	20.00	2,400
79	Gallery Drains	"	9	200.00	1,800
80	Roof Drains	"	6	50.00	300
81	Roof Surfacing	Square 100sf	8	20.00	160
82	Rolled Gravel Surface	Sq.Yd.	15,300	.25	3,825
83	Flagstone Steps	" "	50	.60	30
84	Stone Wall	Cu.Yd.	120	9.00	1,080
85	Gravel	" "	35,000	.90	31,500
86	Ballast	" "	11,700	2.50	29,250
87	Cross Ties	Each	11,000	2.00	22,000
88	Track Laying	TrackFt	19,600	1.50	29,400
89	Field Office	Sum	Job		6,500
90	Field Office Extension	"	"		3,100
			Total Cost		$8,857,975

LONG SAULT DAM

Estimate of Cost - March 18, 1942

Materials and Equipment Furnished by the Government

Item No.	Designation	Unit	Quantity	Unit Price $	Amount $
1	Fine Aggregate	Ton	430,000	1.25	537,500
2	Coarse Aggregate	"	925,000	1.10	1,017,500
3	Portland Cement	Bbl.	642,000	2.50	1,605,000
4	Structural Steel	Lb.	7,500,000	.07	525,000
5	Reinforcing Steel	"	5,000,000	.04	200,000
6	Steel Rails & Accessories	"	781,000	.06	46,860
7	Spillway Gates	"	14,605,000	.125	1,825,625
8	Gantry Cranes	Each	2	200,000	400,000
9	Fixed Hoists	"	18	40,000	720,000
10	Cofferdam Timber	M.B.M.	5,200	100.00	520,000
*11	Electrical Contract	Sum	Job		200,000
12	Passenger Elevator	"	"		15,000
**13	Miscellaneous Equipment	"	"		100,000
			Total Cost		$7,712,485

*Includes electrical substation and power line, wiring, conduits, gate hoist controls and indicators, heaters, etc.

**Includes water supply, ventilating equipment, telephone equipment, gauges, tools, spare parts, supplies, etc.

ST. LAWRENCE RIVER PROJECT

FINAL REPORT 1942

BARNHART ISLAND POWER HOUSE SPECIFICATIONS

DOCUMENTS Room 8

UNIVERSITY OF CONNECTICUT
THIS
PROPERTY
OF
LIBRARY

CORPS OF ENGINEERS, U.S. ARMY

U.S. ENGINEER OFFICE • MASSENA, NEW YORK.

APPENDIX III-24 (2)

S T. L A W R E N C E R I V E R

P R O J E C T

* * * * *

F I N A L R E P O R T

1 9 4 2

B A R N H A R T I S L A N D

P O W E R H O U S E

S P E C I F I C A T I O N S

CORPS OF ENGINEERS, U.S. ARMY

U.S. Engineer Office - Massena, New York

July , 1942

APPENDIX III-24 (2)

This appendix consists of three parts as follows:

PART ONE - GENERAL SPECIFICATIONS.

PART TWO - SPECIFICATIONS for TURBINES and GOVERNORS.

PART THREE - SPECIFICATIONS FOR GENERATORS.

PART ONE

BARNHART ISLAND POWERHOUSE

GENERAL SPECIFICATIONS

Invitation No. _____

No. _____ Bidder _____

(Do not write above this line)

STANDARD GOVERNMENT FORM OF INVITATION FOR BIDS

(CONSTRUCTION CONTRACT)

WAR DEPARTMENT
UNITED STATES ENGINEER OFFICE
MASSENA, NEW YORK
_____, 1941

1. SEALED BIDS, in duplicate, subject to the conditions contained herein, will be received until 2:00 p.m. E.S.T., _____ and then publicly opened in the United States Engineer Office, Massena, New York, for furnishing all labor, plant, and materials, and performing all work for the construction of Barnhart Island Power House, on the St. Lawrence River, about 8 miles northeast of the village of Massena, New York, all as indicated on the drawings or required by the specifications.

2. SPECIFICATIONS AND PLANS.

(a) The work shall be done in strict accordance with the specifications and drawings which are designated as follows:

(1) Barnhart Island Power House, specifications.

(2) The drawings which will become a part of this contract are designated in paragraph 1-04 of the specifications.

(b) Where copies of drawings are requested, a deposit of twenty-five dollars ($25.00) will be required to insure their return. The deposit should be in the form of a United States money order or a certified check made payable to "The Treasurer of the United States." The deposit will be refunded upon the return of the plans in good condition within 30 days after date of opening bids.

3. INVESTIGATION OF CONDITIONS. - Bidders are expected to visit the locality and site of the work, and to make their own estimates of the facilities needed, and the difficulties attending the execution of the proposed contract, including local conditions, availability of labor, uncertainty of weather, and other contingencies. In no case will the Government assume any responsibility whatever for any interpretation, deduction, or conclusion drawn from the examination of the site. At the bidder's request, a representative of the Government will point out the site of the proposed operation. Failure to acquaint himself with all available information concerning these conditions will not relieve the successful bidder of assuming all responsibilities for estimating the difficulties and costs of successfully performing and completing the work. (See paragraphs 1-18 and 1-19 of the specifications.

4. WAGE AND LABOR PROVISIONS. - Wage, labor, and anti-discrimination regulations will be as specified in paragraph 1-38 of the specifications and Articles 11 (Revised), 17, and 19 (Revised) of the contract. Attention of bidders is invited to War Department labor policy for defense construction projects set out in memorandum of agreement approved July 22, 1941. Successful bidders will be expected to adhere to provisions of the agreement, copies of which are on file at the office of District Engineer, U. S. Engineer Office,

Massena, New York.

5. DOMESTIC PREFERENCE. - Articles on the preference for domestic articles will be made a part of the contract. (See paragraph 1-35 of the specifications.)

6. ARTICLES ON PATENTS will be made a part of the contract. (See paragraph 1-30 of the specifications.)

7. COMMENCEMENT AND COMPLETION. - The work shall be commenced within _____ calendar days after date of receipt of notice to proceed and shall be completed within _____ calendar days after date of receipt of notice to proceed, in accordance with the provisions of paragraph 1-06 of the specifications.

8. EXTENSION OF TIME FOR COMPLETION OF CONSTRUCTION FOR DELAYS DUE NATIONAL DEFENSE PRIORITIES will be made. (See paragraph 1-06 (c) of the specifications.)

9. LIQUIDATED DAMAGES for delay will be prescribed. (See paragraph 1-06 of the specifications.)

10. PARTIAL PAYMENTS will be made. (See paragraph 1-08 of the specifications and Article 16 of the contract.)

11. ADJUSTMENT OF CONTRACT PRICE by reason of change in Federal, State, and local taxes will be made. (See paragraph 1-42 of the specifications.)

12. ADJUSTMENT OF PRICES FOR LABOR AND MATERIALS. Adjustment of prices in accordance with basic increase or decrease of costs of labor and materials will be made as provided in paragraph 1-46 of the specifications.

13. ESTIMATES OF COST. - Bidders are informed that the Government will prepare an estimate of the cost of construction of the work required by the specifications for comparison with the bids.

14. REPORTS TO THE DEPARTMENT OF LABOR. - In order to assist the Department of Labor in obtaining employment statistics, bidders, unless otherwise indicated in their bids, will be considered as having voluntarily consented, without cost to the Government, to the inclusion of paragraph 1-39 of the specifications as a part of the contract.

15. BID AND CONTRACT.

(a) Bids must be submitted upon the standard Government form of bid, and the successful bidder will be required to execute the standard Government form of contract for construction (U. S. Standard Form No. 23). Bidders are advised that Article 11 (a) of U. S. Standard Form No. 23 has been revised to permit laborers and mechanics to work more than 8 hours per day, provided overtime compensation at a rate of not less than 1-1/2 times the basic rate of pay is paid for all working time of each laborer or mechanic in excess of 8 hours in any one day. Also Article 19, Nonrebate of U. S. Standard Form No. 23, is revised to read as follows, and the contract to be entered into as a result of this invitation will be altered accordingly:

"ARTICLE 19. Nonrebate. (a) The contractor shall furnish to the Government representative in charge at the site of the work covered by this contract, or if no Government representative is in charge at the site, shall mail to the Federal agency contracting for the work, within 7 days after the regular payment date of each and every weekly pay roll, an affidavit in the form prescribed by regulations issued by the Secretary of Labor and published in the Federal Register of March 1, 1941, 6 F. R. 1211, or any modification thereof pursuant to the act of June 13, 1934, 48 Stat. 948 (U. S. Code title 40, sections 276b and 276c), sworn to by the contractor or the subcontractor concerned or by the authorized officer or employee of the contractor or subcontractor supervising such payment, to the effect that each and every person employed on the work has been paid in full the weekly wages shown on the pay roll covered by the affidavit, that no rebates have been or will be made either directly or indirectly to or on behalf of the contractor or such subcontractor from the full weekly wages earned as set out on such payroll; and that no deductions, other than permissible deductions as defined in the said regulations pursuant to said act of June 13, 1934, and as described in said affidavit, have been or will be made, either directly or indirectly, from the full weekly wages earned as set out on such pay roll.

"(b) The contractor shall comply with all applicable requirements of the said regulations of the Secretary of Labor under the act of June 13, 1934, and the requirements of this article of the contract shall be subject to all applicable provisions of such regulations.

"(c) The contractor shall cause appropiate provisions to be inserted in all subcontracts related to this work to insure fulfillment of the requirements of this article."

(b) The bid form has an entry for each item on which estimates will be given or payments made, and no other allowance of any kind will be made unless specifically provided for in the specifications or the contract, or adjustments under Article 3 of the contract.

(c) All bids must be for the entire work and must have each blank filled.

(d) The quantities of each item of the bid as finally ascertained at the close of the contract, in the units given, and the unit price of the several items stated by the bidder in the accepted bid, will determine the total payments to accrue under the contract. The unit price bid for each item must allow for all collateral or indirect cost connected with it.

16. DATA TO BE SUBMITTED WITH BIDS.

(a) All bids submitted must be accompanied by a statement establishing that the bidder maintains a permanent place of business and has a suitable financial status to meet obligations incident to the work. (See paragraph 3 of the bidding schedule.) In addition, each bidder shall submit with his bid the statement of plant, drawings, charts, and other information and data required below. These data shall be carefully prepared and presented in neat and legible form on tracing paper or tracing cloth so that reproduction may be made therefrom. These data are considered essential in enabling the contracting officer to determine whether the bidder is responsible and experienced in similar types of construction and whether the bid is based on a careful study of construction methods applicable to the work and full realization of the various factors which may affect the progress of the work. Award of this contract shall not be construed as a guarantee by the Government that the materials, equipment or supplies listed in the bidding schedule are approved.

(b) Each bidder shall state in the space provided in the bidding schedule a brief description of the character of the work previously executed by him and the locations of the major projects. After the bids are opened, any bidder may be required by the contracting officer to state whether he is now or ever has been engaged on any construction work similar to that proposed, the year in which it was done, and the manner of its execution, and to give such other information as will tend to show his ability to prosecute vigorously the work required by these specifications. (See paragraph 2 of the bidding schedule.)

(c) Drawings shall be submitted indicating the plant lay-out the bidder proposes to utilize on the work. The drawings shall clearly indicate the location and manner of employment of the various major items of the plant. They shall include the location, construction, and height of each cofferdam if contractors plan differs from contracting officers plan, the arrangement of the plant for the handling of materials, and the manner in which excavation and disposal of the excavated materials will be made. They shall also include the location of all material yards and the transportation facilities, as well as the location of the mixing plant and the manner in which concrete materials will be handled and concrete transported and placed and metalwork erected. The plant lay-out shall be accompanied by a complete list and description inserted in the space provided therefor in the bid form, of all plant that the bidder now has or will have available for commencing and prosecuting this work, and its location at the time of opening bids, in order that it may be inspected by the contracting officer should he so desire. The above information will be considered confidential. When a bidder does not own or possess plant and proposes to procure it, firm options on all major items of proposed plant must be submitted when the bids are opened.

(d) A chart or charts shall be submitted indicating the volume of work to be done and the rate of progress which the bidder agrees to maintain (See paragraph 1-20 of the specifications) for each of the following major operations required in the performance of the work under these specifications:

(1) Cofferdams, (Construction and Removal).
(2) Excavation and Foundation Preparation.
(3) Embankment.
(4) Concrete Masonry.
(5) Turbine Embedded Parts.
(6) Structural Steel
(7) Gate Guides, Gates and Fixed Hoists.
(8) Cranes and Overhead.
(9) Access Highway and Railroad

Charts shall be in the form of plotted curves in which the abscissae shall represent definite intervals of time measured from date of receipt of notice to proceed with the work, and the ordinates shall represent percentages of completion based on the estimated contract quantities. In preparing the charts, due allowance shall be made for probable delays caused by any unsatisfactory working conditions. Careful consideration shall be given to the preparation of these charts, as the rate of progress proposed by the accepted bid will be made a part of the contract. (See paragraph 1-20 of the specifications.)

17. AWARD OF CONTRACT.

(a) Subject to the rights hereinafter reserved, work will be awarded as a whole to the lowest responsible bidder whose proposal fully conforms to the requirements of the specifications and as may be deemedmost

advantageous to the United States.

(b) A bid may be rejected if the bidder fails to furnish a bid bond or to submit the data required with his bid or cannot show that he has the necessary capital and experience and owns, controls, or can procure the necessary plant to commence the work at the time prescribed in the specifications and thereafter to prosecute and complete the work at the rate or time specified; and that he is not already obligated for the performance of other work which would delay the commencement, prosecution, or completion of the work contemplated in this advertisement.

(c) Any unbalanced bid which, in the opinion of the contracting officer, jeopardizes the interest of the United States will be subject to rejection for that reason.

(d) The right is reserved, as the interest of the Government may require, to reject any and all bids, and to waive any informality in bids received.

18. GUARANTY. - Guaranty will be required with each bid as follows: Bid Bond, Standard Form No. 24, will be executed in a penal sum not less than 10 percent of the total amount of the bid, but not exceeding $2,500,000.00. Individual sureties will justify in sums aggregating not less than double the penalty of the bid bond. (See paragraphs 8 and 9 of the Instructions to Bidders.)

19. PERFORMANCE AND PAYMENT BONDS will be required as follows:

(a) A performance bond with good and sufficient surety or sureties, for the protection of the United States, Standard Form No. 25, will be executed in a penal sum not less than ten percent (10%) of the full amount of the consideration of the contract, but not to exceed two million five hundred thousand dollars ($2,500,000.00).

(b) If the consideration of the contract will exceed $2,000 in amount, a payment bond with good and sufficient surety or sureties, for the protection of persons furnishing material and labor for the work, Standard Form No. 25-A, will be executed in a penal sum of one-half of the full amount of the consideration of the contract when the latter is not more than one million dollars ($1,000,000); forty percent (40%) where the contract exceeds one million dollars ($1,000,000) but is not more than five million dollars ($5,000,000); and two million five hundred thousand dollars ($2,500,000) for all contracts above five million dollars ($5,000,000).

20. PROVISIONS OF THE ASSIGNMENT OF CLAIMS ACT of October 9, 1940, (Public No. 811-76th Congress) will be made a part of the contract. (See paragraph 1-45 of the specifications.)

21. ADDRESS FOR BIDS. - Envelopes containing bids must be sealed, marked, and addressed as follows:

Mark in upper left hand corner:

Bid for Construction of
Barnhart Island Power House

Invitation No. _____
To be opened at 2:00 P.M. E.S.T.,

Address:

To: The District Engineer
U. S. Engineer Office
Massena, New York

Note: See Standard Government Instructions to Bidders and copy of the Standard Government Form of Contract, Bid Bond, Payment Bond, and Performance Bond, which may be obtained upon application.

Specifications: Barnhart Island Power House

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WAR DEPARTMENT
U. S. ENGINEER OFFICE
ST. LAWRENCE RIVER DISTRICT
MASSENA, N. Y.

Specifications: Barnhart Island Power House

Appropriation:

SECTION I - GENERAL PROVISIONS

1-01. LOCATION. - The site of the work is located in the international Rapids Section of the St. Lawrence River, about 8 miles northeast of the village of Massena, New York, and two miles west of Cornwall, Ontario. The site may be reached by Federal and State Highways on the United States side of the St. Lawrence River and by Highway No. 2 on the Canadian side.

1-02. WORK TO BE DONE. -

(a) The work provided herein is authorized by ---------- Act, approved _____, 1941.

(b) The work to be done under this contract and in accordance with these specifications consist of furnishing all plant, superintendence, labor and materials, except as noted in paragraph 1-10, and performing all work required for the construction of the Barnhart Island Power House complete in accordance with the drawings and these specifications, except for items of work listed in paragraph (c) below. The main features of the work are as follows:

(1) Excavation for and construction of cofferdams including maintenance, unwatering and removal, (See Section II).

(2) Excavation for foundations of concrete structures including foundation preparation and grouting, excavation of core trench and stripping foundation for earth fill. (See Section III).

(3) Construction of rolled earth fill dikes complete, including stripping foundation, placing and compacting embankment, placing protective riprap, and seeding. (See Section IV).

(4) Placing concrete, reinforcement, and embedded parts for the Power House and appurtenant works. (See Section V).

(5) Installation of embedded parts for the turbines. (See Section ___).

(6) Furnishing and erecting the structural steel building frame and other structural steel and miscellaneous metal work. (See Section ____).

(7) Erection and installation of gates with guides, sills and fixed hoists, trash racks and guides, and stop logs and guides. (See Section XII).

a. For intakes and draft tubes for 36 main units.
b. For intakes and draft tubes for 2 house units.
c. For six ice sluiceways.

(8) Erection and installation of 4 overhead cranes, 3 overhead erection bay cranes, 2 draft tube stop log gantry cranes and 2 intake gate gantry cranes. (See Section ___).

(9) Permanent access railroad and highway. (See Section __).

(10) Miscellaneous items including embedded electrical conduit system, embedded piping for water, drainage, and other purposes,

government field office, and other work as specified or shown on the drawings listed in paragraph 1-04, and detail drawings to be furnished at latter date and such incidental work as may be needed or ordered in writing by the contracting officer.

(c) Some of the main features of work not included in this contract are the installation of turbines, generator and all electrical equipment needed for power generation and distribution; the interior finish and plumbing, heating, and ventilating systems not embedded in concrete; sump pumps, valves, etc., and other items specifically excepted in these specifications.

1-03. DESCRIPTION. - Barnhart Island Power House will be a reinforced concrete structure having a maximum height of approximately 160 feet above the foundation and a over all length of approximately 3650 feet. It will house 18 main units and one house unit on the United States side and same number on the Canadian side. Each main unit will have three intake service gates. Permanent intake and draft tube stop logs will be provided for four units. Construction draft tube stop logs will be provided for all other units. (See paragraph 12-01). There will be four traveling cranes in the generator room and three traveling cranes in the erection bays. There will be two gantry cranes to handle draft tube stop logs and two gantry cranes to handle intake service gates, ice gates, and stop logs. Each end of the house will have a concrete gravity wingdam at the southend, an earth dike will extend about 8,000 feet to high ground. At the north end, an earth dike will extend about 800 feet to join a similar dike to be constructed by others.

1-04. MAPS AND DRAWINGS.

(a) The work shall conform to maps and drawings marked "St. Lawrence River Project, Barnhart Island Power House", titled and file marked as listed below, which form a part of these specifications and which are filed in the U. S. Engineer Office, St. Lawrence River District, Massena, New York.

GENERAL DRAWINGS

Sheet No.	File No.	Title
1	B.P-1-0/1	Index
2	B.P-1-1/1	General Site Map
3	B.P-1-1/2	Mean Monthly Discharge, St. Lawrence River-1860 to 1941
4	B.P-1-1/3	Winter Tailrace Elevations, Sheek Island Powerhouse
5	B.P-1-2/1	Plan of Exploration No. 1
6	B.P-1-2/2	" " " No. 2
7	B.P-1-2/3	Record of Exploration No. 1
8	2/4	" " " No. 2
9	2/5	" " " No. 3
10	2/6	" " " No. 4

COFFERDAMS

11	B.P-1-5/1	Cofferdam General Layout
12	5/2	" Details

POWERHOUSE

Sheet No.	File No.	Title
13	B.P.-1-15/1	General Plan and Sections
14	15/2	Excavation
15	15/3	Upstream Wing Wall Canadian Powerhouse
16	15/4	" " " United States Powerhouse
17	15/5	Downstream Wing Wall " " "
18	15/6	Transverse Section Thru Main Unit
19	15/7	Transverse Section Thru Drainage Pump Rooms and Sumps
20	15/8	" " " " Valve Rooms
21	15/9	" " " Center Ice Sluice
22	15/10	" " " House Unit
23	15/11	" " " Erection Bay Block C, US Powerhouse
24	15/12	" " " Erection Bay Block C, US Powerhouse
25	15/13	" " " Block 19 Above El. 163.0 US Powerhouse
26	15/14	Longitudinal Section A-A.
27	15/15	" " "
28	15/16	Plans at El. 137.0 Floor, Showing Typical Blocks
29	15/17	" " " " Blocks 6,12,25, and 31.
30	15/18	" " " " " 18,H-1, and part of B. Canadian Powerhouse
31	15/19	" " " " " H-2, 19 and part of B. U.S. Powerhouse
32	15/20	" " " " " 36 and C., U.S. Powerhouse
33	B.P-1-15/21	Plan at C.L.Distributor and El. 149.0 Floor, Typical Blocks
34	15/22	" " " " " " Stair and Elevator Blocks, 6,12,25, and 31.
35	15/23	" " Distributor and El. 149.0 Floor, Blocks 18, H-1 and part of B. Canadian Powerhouse
36	15/24	" " Distributor and El. 149.0 Floor, Blocks H-2, 19 and part of B. U.S. Powerhouse
37	15/25	" " Distributor and El. 149.0 Floor, Blocks 36 C. U.S. Powerhouse
38	15/26	" at Turbine Floor, Typical Blocks
39	15/27	" " " " Stair and Elevator blocks 6, 12,25, and 31.
40	15/28	" " " " Blocks 18,H-1, and part of B. Canadian Powerhouse
41	15/29	" " " " Blocks H-2,19, and part of B. U.S. Powerhouse
42	15/30	" " " " Blocks 36 and C. U.S. Powerhouse
43	15/31	" " El. 197.5 Floor, Typical Blocks
44	15/32	" " " " " Stair and Elevator Blocks 6, 12,25,and 31
45	15/33	" " " " " Blocks 18,H-1, and part of B. Canadian Powerhouse
46	15/34	" " " " " Blocks H-2,19, and part of B. U.S. Powerhouse.
47	15/35	" " " " " Blocks 36 & C.,U.S. Powerhouse
48	15/36	" " " 209.0 Floor, Typical Blocks

Sheet No.	File No.	Title
49	B.P-1-15/37	Plan at El.209.0 Floor, Blocks 6,12,25 and 31.
50	15/38	" " " " " 18,H-1 & part of B. Canadian Powerhouse
51	15/39	" " " " " H-2,19 & part of B. U.S. Powerhouse
52	15/40	" " " 227.0 & 243.5 Floors & roof, all Turbine Blocks
53	15/41	" " " 209.0, 227.0 & 231.5 Floors, Blocks 36 & C. U.S. Powerhouse
54	15/42	" " " 243.5 & 256.0 Floors, Blocks 36 & C. U.S. Powerhouse
55	15/43	" " " 231.5, 248.5 & 260.0 Floors, office portion of Block C. U.S. Powerhouse
56	15/44	" " " 275.0 Floor, office portion of Block C. U.S. Powerhouse
57	15/45	" of Roof Blocks 36 and C. U.S. Powerhouse
58	15/46	" " El. 227.0 & 243.5 Floors, Blocks 19,H-2 & part of B. U.S. Powerhouse
59	15/47	" " El. 248.0, 256.5, 268.0, 282.0 Floors, Blocks 19, 20,H-2 & B. U.S. Powerhouse
60	15/48	" " Roof, Blocks 19,H-2, and part of B. U.S. Powerhouse
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62	15/50	Elevators
		EMBANKMENT
63	B.P-1-20/1	North & South Forebay Dikes
		GOVERNMENT FIELD OFFICE
64	B.P-1-160/1	Plan & Elevation
65	160/2	Utilities
		ACCESS HIGHWAY
66	B.P-1-185/1	Plan & Profile No. 1
67	185/2	" " " No. 2
68	185/3	Details
69	185/4	Typical Highway Sections
		ACCESS RAILROAD
70	195/1	Plan & Profile No. 1
71	195/2	" " " No. 2
72	195/3	Details
73	195/4	Typical Railroad Section

(b) These drawings show the work with as much detail as is possible in the present stage of development of the design. The work shall conform also to such other drawings and addenda relating thereto as may be published and/or exhibited in the office of the contracting officer prior to the opening of proposals, and to such drawings in explanation of details

as may be required from time to time during construction, including such modifications as the contracting officer may consider necessary on account of conditions that are found to exist during the prosecution of the work.

(c) Prior to the execution of the work the contractor shall check all drawings and shall immediately report to the contracting officer any errors or omissions discovered therein. Errors and/or omissions in drawings will not relieve the contractor of his responsibility for the correct fitting together and exact position of all parts of the work in accordance with the specifications. Parts and details not fully indicated on the drawings shall be detailed by the contractor in accordance with the best practice, or as directed by the contracting officer. The contractor shall submit detail reinforcing steel cutting and bending schedules, and fabricator's shop drawings of all structural steel and other metal work for approval. He shall also submit such shop drawings and materiallists of all mechanical and electrical equipment as may be required by the contracting officer. No material shall be furnished or work done thereon prior to approval of these drawings. The contractor shall submit three (3) prints of each of such detailed drawings to the contracting officer who will return one print with his approval or notations of such changes as he finds necessary. Each print submitted for approval shall have in the lower right-hand corner just above the title a white space 3 inches by 4 inches in size in which the contracting officer will indicate the action taken. After approval, the contractor shall furnish the contracting officer one tracing and five prints of each approved drawing. Three copies or sets of parts catalogs, spare parts listed and operating instructions shall be furnished as specified above or as requested by the contracting officer. Payment for the contractor's drawings, including revisions thereof, parts catalogs, spare parts lists and operating instructions shall be included in the contract prices paid for material or work. All of these items will form a part of the contract when approved by the contracting officer.

(d) Ten sets of prints of necessary contract drawings(one-half size reproductions, or full size if desired) and twenty sets of specifications will be furnished the contractor without charge. Additional prints may be secured upon request at the cost of reproduction.

1-05. QUANTITIES. - The following estimate of quantities of work to be performed is given only to serve as a basis for canvassing bids and for determining the approximate amount of the consideration of the contract. Unless the contract is terminated by the failure of Congress to appropriate additional funds (see paragraph 1-08), the contractor will be required to complete the work specified in paragraph 1-02 hereof, be the required quantities more or less than the amounts shown herein.

QUANTITIES

Item No.	Paragraph Reference	Designation	Unit	Quantity
1	2-08(a)	Timber Cribs	M.B.M.	2,100
2	2-08(b)	Crib Sheathing	Sq.Ft.	28,000
3	2-08(c)	Steel Sheet Piling	Sq.Ft.	27,500
4	2-08(d)	Crib Fill	Cu.Yd.	48,000
5	2-08(e)	Earth Fill; Compacted Class I, Cofferdam	Cu.Yd.	46,000
6	2-08(e)	Earth Fill; Compacted Class II, Cofferdam	Cu.Yd.	645,000
7	2-08(e)	Earth Fill; Class III, Cofferdam	Cu.Yd.	185,000

Item No.	Paragraph Reference	Designation	Unit	Quantity
8	2-08(e)	Rock Fill; Cofferdam	Cu.Yd.	135,000
9	2-08(e)	Riprap; Cofferdam	Cu.Yd.	49,200
10	2-08(i)	Unwatering Cofferdams	Ac.Ft.	90,000
11	2-08(j)	Cofferdam Removal	Cu.Yd.	776,300
12	3-07(b) 15-04 15-09(b) 14-05(a)	Excavation; Common	Cu.Yd.	3,821,000
13	3-07(b)	Excavation; Rock	Cu.Yd.	225,000
14	3-09(b)	Line Drilling	Sq.Ft.	40,000
15	4-02(e)	Excavation; Borrow	Cu.Yd.	250,000
16	3-11(g)	Drilling Exploratory Holes, 0 to 30 ft.	Lin.Ft.	1,250
17	3-11(g)	Drilling Exploratory Holes, 30 to 60 ft.	Lin.Ft.	1,350
18	3-11(g)	Drilling Exploratory Holes, 60 ft. and over	Lin.Ft.	2,500
19	3-11(g)	Drilling Grout Holes in Rock 0 to 30 ft.	Lin.Ft.	3,750
20	3-11(g)	Drilling Grout Holes in Rock 30 to 60 ft.	Lin.Ft.	7,800
21	3-11(g)	Drilling Grout Holes in Rock 60 ft. and over	Lin.Ft.	4,250
22	3-11(g)	Drilling Grout Holes in Concrete	Lin.Ft.	2,000
23	3-13(c)	Drilling 6-inch Drain Holes	Lin.Ft.	15,000
24	3-14(b) 5-10(c)	Drilling 6-inch Concrete Cores	Lin.Ft.	1,000
25	3-11(g)	Core Boxes	Each	1,800
26	3-11(g) 5-18(g)	Grout Pipes and Connections	Lb.	125,000
27	3-13(c)	Pipe; Black Steel, 8" Diam.	Lb.	53,000
28	3-12(e) 5-18(g)	Pressure Grouting	Cu.Ft.	50,000
29	3-12(e) 5-18(g)	Sand in Grout	Cu.Ft.	2,500
30	3-12(e) 5-18(g)	Rock Flour in Grout	Cu.Ft.	3,000
31	4-03(b) 4-04(i)	Earth Fill; Compacted Class I	Cu.Yd.	1,580,000
32	4-03(b) 4-04(i) 15-04	Earth Fill; Compacted Class II	Cu.Yd.	103,000
33	4-04(i)	Additional Compaction	Square	250,000
34	4-05(b)	Earth Fill; Class III	Cu.Yd.	250,000
35	4-08(c)	Rock Fill	Cu.Yd.	151,000
36	4-08(c)	Riprap; Dumped, Class A	Cu.Yd.	75,000
37	4-08(c)	Riprap; Dumped, Class B	Cu.Yd.	90,000
38	2-08(g) 4-07(c)	Sand & Gravel Backing	Cu.Yd.	58,600

Item No.	Paragraph Reference	Designation	Unit-	Quantity
39	2-08(h) 4-06(c)	Filter	Cu.Yd.	101,300
40	4-09(d)	Seeding	Acre	15
41	5-23(a)	Concrete, Class A	Cu.Yd.	134,000
42	5-23(a)	Concrete, Class B	Cu.Yd.	281,000
43	5-23(a)	Concrete, Class C	Cu.Yd.	1,503,000
44	5-13(i)	Straight Concrete Forms	Sq.Ft.	7,100,000
45	5-13(i)	Concrete Forms Curved One Way	Sq.Ft.	446,000
46	5-13(i)	Concrete Forms Curved Two Ways	Sq.Ft.	460,000
47	5-13(i)	Absorptive Form Lining	Sq.Ft.	2,200,000
48	5-13(i)	Concrete Forms For Ceilings	Sq.Ft.	600,000
49	5-13(i)	Concrete Forms For Construction Joints	Sq.Ft.	3,820,000
50	5-11(b)(9)	Monolithic Concrete Floor Finish	Sq.Ft.	160,000
51	5-14(i) 5-15(b)(2) 9-04(a)	Reinforcing Steel	Lb.	108,000,000
52	5-15(c)	Drilling Holes For, and Placing Dowel Bars	Lin.Ft.	1,000
53	5-16(c)	Metal Reglets	Lin.Ft.	17,000
54	5-21(e)	Membrane Waterproofing	Square	1,250
55	5-21(e) 12-09	Copper Metal Work	Lb.	80,000
56	5-18(f)	Copper Water Stops	Lb.	40,000
57	5-21(e)	Lead Sleeves and Flanges	Lb.	15,000
58	5-18(g)(2) 10-10	Sheet Iron and Steel	Lb.	65,000
59	5-18(f)	Special Bituminous Filler, Type C	Cu.Ft.	3,500
60	5-18(f)	Halved Concrete Pipe	Lin.Ft.	11,000
61	5-19(b) 9-06 10-18	Poured Grout	Cu.Ft.	115,000
62	5-20(b) 9-06	Special Non-shrink Grout	Cu.Ft.	1,000
63	7-10	Structural Steel	Lb.	19,000,000
64	7-10	Steel Track Rails	Lb.	2,720,000
65	7-10	Miscellaneous Black Steel and Metal Work	Lb.	430,000
66	7-10	Miscellaneous Galvanized Steel and Metal work	Lb.	600,000
67	7-10	Plain Gratings	Lb.	360,000
68	7-10	Galvanized Gratings	Lb.	320,000
69	7-10	Safety Treads and Thresholds	Lb.	110,000
70	7-10	Cast Iron Frames and Covers	Lb.	40,000
71	7-10	Forgings, Steel	Lb.	2,000
72	7-10	Bronze	Lb.	3,000
73	7-10	Miscellaneous Non-ferrous Metals	Lb.	2,000

Item No.	Paragraph Reference	Designation	Unit	Quantity
74	7-10	Pipe Handrail	Lb.	70,000
75	8-05	Conduit and Fittings	Lb.	1,225,000
76	8-05	Outlet Boxes	Lb.	25,000
77	9-06	Turbine Embedded Parts, Installation	Ton	5,500
78	10-18	Installing Guides, Sills and Embedded Parts	Ton	1,664
79	10-18	Installing Gates, Stop Logs, Racks and Gate Hoists	Ton	14,496
80	10-18	Installing Gantry Cranes	Ton	200
81	10-18	Installing Overhead Cranes	Ton	1,520
82	11-18	Steel Pipe and Fittings, Black	Lb.	570,000
83	11-18	Steel Pipe and Fittings, Galvanized	Lb.	750,000
84	5-18(f) 11-18	Wrought Iron Pipe and Fittings	Lb.	27,500
85	11-18	Pickled Wrought Iron Pipe and Fittings	Lb.	500
86	11-18	Cast Iron Pipe and Fittings	Lb.	1,500,000
87	11-18	Duriron Pipe and Fittings	Lb.	500
88	11-18	Forged Steel Fittings	Lb.	1,000
89	11-18	Coating Underground Pipe and Fittings	Lb.	4,000
90	11-18	Brass Pipe and Fittings	Lb.	12,600
91	11-18	Copper Tubing and Fittings	Lb.	100
92	11-18	Inserts, Pipe Hangers and Supports	Lb.	500
93	11-18	Brass valves	Lb.	500
94	11-18	Iron-body Valves, Brass or Bronze Mounted	Lb.	67,500
95	11-18	Roof Drains	Lb.	7,100
96	11-18	Floor and Deck Drains, Brass or Bronze Strainers	Lb.	6,000
97	11-18	Floor and Trench Drains, all Cast Iron	Lb.	6,000
98	12-09	Precast Concrete Roof Slabs	Square	1,400
99	12-09	Precast Concrete Roofing Tile	Square	2,900
100	12-09	Built-up Asphalt Roofing	Square	1,400
101	12-09	Lead Collar for 4-inch Toilet Vent	Each	10
102	14-01(c)	Tile Gage	Lin.Ft.	70
103	14-02(c)	Glass Block	Sq.Ft.	20,500
104	14-05(a)	Storm Drain Pipe, 10-inch	Lin.Ft.	525
105	14-05(a)	Storm Drain Pipe, 12-inch	Lin.Ft.	525
106	14-05(a)	Storm Drain Pipe, 18-inch	Lin.Ft.	400
107	14-05(a)	Storm Drain Pipe, 24-inch	Lin.Ft.	950
108	14-05(b)	Concrete Cradle for Storm Drain Pipe	Cu.Yd.	30
109	14-05(c)	Catch Basins, Rectangular	Each	19
110	14-05(c)	Catch Basins, Circular	Each	6

Item No.	Paragraph Reference	Designation	Unit	Quantity
111	14-05(d) 15-12(b)	Culvert Head Walls, Standard	Each	28
112	2-08(f)	Pipe; Corrugated Iron, 12-inch Diameter	Lin.Ft.	800
113	15-12(b)	Pipe; Corrugated Iron, 12-inch Diameter	Lin.Ft.	268
114	15-12(b)	Pipe; Corrugated Iron, 30-inch Diameter	Lin.Ft.	254
115	15-11(b)	Gravel Fill Base	Cu.Yd.	7,230
116	15-13(c)	Ballast	Cu.Yd.	6,200
117	15-14(c)	Cross Ties	Each	7,240
118	15-15(c) 15-16(b)	Track Laying	Track Ft.	16,185
119	15-17(d)	Road Surfacing	Sq.Yd.	29,000
120	15-18(b)	Highway Guard Rail	Lin.Ft.	7,460
121	16-26	Field Office	Sum	Job
122	16-26	Field Office Extension	Sum	Job

1-06. COMMENCEMENT, PROSECUTION AND COMPLETION

(a) The contractor will be required to commence work under the contract within ___ calendar days after the date of receipt by him of notice to proceed, to prosecute the said work with faithfulness and energy, and to complete the entire work within ___ calendar days after said date of receipt by him of notice to proceed, plus any extensions of time duly granted under the provisions of the contract and specifications. The work shall be prosecuted as vigorously as practicable during all seasons of the year.

(b) (1) The schedule of work on this contract will correlate with the schedule of work by other construction contracts, particularly those for the construction of Long Sault Dam.

(2) The powerhouse contractor shall schedule his work in such manner to meet the requirements of the schedule set up for the date of raising the pool. The start of raising the pool above El. 210.0 will begin ___ days after receiving notice to proceed, and the pool will be raised to elevation 230 within ____ days after receiving notice to proceed.

(3) In case of failure on the part of the powerhouse contractor to have his work completed to such extent that the raising of the pool is delayed, the powerhouse contractor shall pay to the Government as liquidated damages the sum of $1,000 a day for each calendar day of delay until the work is ready to allow the Long Sault Dam contractor to start raising the pool.

(4) In case of failure on the part of the contractor to complete the entire work within the time thus determined and agreed upon for its completion, the contractor shall pay to the Government as liquidated damages the sum of $500 for each calendar day of delay until construction is completed and the powerhouse is placed in operating condition as determined by the contracting officer.

(5) Should the construction be completed and placed in operating condition except for minor finishing work as determined by the contracting officer, the contracting officer may conditionally accept and occupy the work; and thereafter the contractor shall pay to the Government, as liquidated damages the sum of $100.00 for each calendar day of delay

until all the items and minor finishing work have been completed and accepted.

(6) In the event the entire structure has been completed and accepted and all work under the contract has been completed except for removal of contractor's plant and buildings and restoration of the site, no further liquidated damages will be assessed, but final payment will not be made until this latter work has been accomplished as required.

(c) If the completion of the undertaking to be performed under the terms of this contract be delayed by reason of delay in the delivery of materials or supplies essential to such performance because of national defense priorities and without the fault or negligence of the contractor, the time of performance will be extended for a period equal to such delay, as determined by the contracting officer, and subject to appeal, as provided in Article 9 of the contract.

1-07. SUNDAYS, HOLIDAYS AND NIGHTS. Work on Sundays, holidays, and nights will be at the option of the contractor. However, when the contractor elects to work at such times notice of his intention to do so shall be given the contracting officer within a reasonable time in advance thereof.

1-08. PAYMENTS.

(a) (Availability of Funds?)

(b) Payments will be made monthly on estimates of work performed in accordance with the contract and not included in any prior estimate, except that ten percent (10%) of the amount of each estimate will be retained until the total amount retained is ____ dollars (____), and this amount will be retained until it equals ten percent (10%) of the remaining work to be done. Thereafter with each monthly payment there will be paid such portion of the amount so retained as is in excess of ten percent (10%) of the work remaining to be done until the amount retained is reduced to _____ dollars (_____), which amount will be retained until the completion of the contract when final payment will be made.

1-09. WORK COVERED BY CONTRACT.

(a) The contractor shall, under his contract prices, furnish and pay for all materials (except as specified in paragraph 1-10), labor and equipment for all permanent, temporary, preparatory and incidental work, furnish all accessories and do everything which may be necessary to carry out the contract in good faith, which contemplates everything completed in good working order, of good material and with accurate workmanship, skillfully fitted and properly connected and put together.

1-10. MATERIALS FURNISHED BY THE UNITED STATES

(a) The following material furnished by the United States will be delivered to the contractor f.o.b., at the site of work.

(1) Cement and Aggregates for concrete.
(2) Cement for Grout.
(3) Intake service gates for main units including hoists and guides.
(4) Intake service gates for house units including hoists and guides.
(5) Ice sluice gates, guides, and hoists
(6) Turbine embedded parts
(7) Intake stop logs and guides

(8) Draft tube stop logs and guides.
(9) Ice sluice stop logs and guides.
(10) Intake trash racks and guides

The contractor shall be responsible that all railroad cars are unloaded promptly and will be held liable for any demurrage charges due to his failure to do so. He will be required to unload, store, and use these materials in accordance with the specifications, and contract drawings.

(b) All materials shall be adequately housed or otherwise protected against deterioration and damage. When material stored at the site is not adequately protected by the contractor, such material will be kept protected by the contracting officer at the expense of the contractor.

(c) Cement. - All cement furnished for concrete except high early strength cement will be a moderate-heat-of-hardening Portland cement conforming to Federal Specification SS-C-206. Cement will be delivered to the contractor at the site of the work at any time after the date of notice to proceed. The contractor shall advise the contracting officer, in writing, at least 30 days in advance of the time he will require the first cement, and thereafter he shall at all times keep the contracting officer informed of his anticipated requirements. Ten days before the first of each month or at such other times as may be directed by the contracting officer, the contractor shall furnish written notice of his future cement requirements for the next 30 days. The contracting officer will at all times expedite the delivery of all orders but the Government will not be liable for any expense or delay caused the contractor by delayed deliveries, except as provided under Article 9 of the contract. Copies of all orders for cement will be furnished promptly to the contractor. The cement will be furnished in bulk except that necessary for grouting and finishing work, which will be furnished in paper bags. Any cement, bulk or bag, which shall be damaged after delivery to the contractor will be paid for by him. Any difference in excess of one-half of one percent between the net quantity of cement delivered to the contractor, and the quantity incorporated in the completed and accepted work will be charged to the contractor, at its cost to the government at the point of delivery to the contractor. The quantity of bulk cement delivered to the contractor will be determined by certified shipping weights. The contractor shall provide, at the site, storage for not less than 20,000 barrels of bulk cement and 500 barrels of bag cement. In order that cement will not become unduly aged after delivery, the contractor shall not use cement in the work directly from the freighting or transporting operations whenever any cement is available, that has been stored more than 60 days after delivery to the contractor. Cement that has been stored for more than 90 days shall be retested at the expense of the contractor. (See paragraph 1-31 (d).) Storage bins for cement shall be so constructed that there will be no dead storage and that adequate protection against the elements will be provided.

(d) Aggregates for Concrete. - All aggregates for concrete will be either natural sand and gravel or crushed rock. Investigations are being continued by the contracting officer for concrete aggregates. The results of these investigations will be made available to interested bidders at the U. S. Engineer Office, Massena, New York, and bidders may also, by request, obtain a copy of the Government Specifications for concrete aggregates to be furnished. Aggregates will be delivered to the contractor at

the site of the work in bottom-dump railroad cars. The contractor shall give at least 30 days written notice to the contracting office in advance of the time he will require the first delivery of aggregates and thereafter he shall at all times keep the contracting officer informed of his anticipated requirements. Ten days before the first of each month or at such other times as may be directed by the contracting officer, the contractor shall furnish written notice of his future aggregate requirements for the next 30 days. The contracting officer will at all times expedite the delivery of all orders but the Government will not be liable for any expense or delay caused the contractor by delayed deliveries except as provided for under Article 9 of the contract. Copies of all orders for aggregate will be furnished promptly to the contractor. Any aggregate lost or misused shall be paid for by the contractor. Any difference in excess of one-half of one percent between the net quantity of aggregate delivered to the contractor and the quantity incorporated in the completed and accepted work will be charged to the contractor at its cost to the Government at the point of delivery to the contractor. The quantity of aggregate delivered to the contractor will be determined by certified shipping weights. Aggregates will be delivered in separate sizes in accordance with paragraph 5-08(f)(1). Aggregates shall be stockpiled and stored in accordance with paragraph 5-07(b).

(e) Cement and aggregates furnished by the Government may be used by the contractor in erecting construction plants and facilities. The contractor will be billed for the actual cost to the Government at the point of delivery for furnishing the materials so used by the contractor. The materials thus used shall not be included in the one-half of one percent tolerance specified above.

(f) The contractor shall check the quantity and condition of all materials delivered to him at the time of unloading, and in case there is damage to, or shortage of cement or aggregates, he shall report to the contracting officer in writing within 24 hours after delivery. If there is any shortage, or damage which in the opinion of the contracting officer is sufficient to cause the materials to be unfit for use in the work, and shortage or damage has not been reported as specified above, the contractor will be charged with the actual cost of replacement of such shortage or damage.

(g) The contractor shall return to the Government f.o.b. cars at the aforementioned point of delivery, all cement furnished by the Government and not used. The contractor will be charged for any cement, not used and not returned, an amount equal to the cost to the Government at the point of delivery to the contractor.

1-11. ELECTRICAL ENERGY DURING THE CONSTRUCTION PERIOD.

(a) The Government will provide a source of electrical energy without cost to the contractor at a point approximately _____ feet from the south abutment. The capacity of this source will be _____K.V.A. at_____volts, 3-phase, 60 cycle. The contractor if he elects to use this power, shall provide, without cost to the Government, all facilities and equipment necessary to furnish himself with electrical energy for power and lighting from the above source. This shall include a meter and metering equipment, transformers, holes, switches, lights, and any other equipment that may be necessary. The contractor will be required to light during the construction period all highways built by him, and all job roads,

galleries within the power house outside work areas, all safety lights (see paragraph 1-22), and any other lighting as directed all to the satisfaction of the contracting officer. The contractor may use permanent government equipment installed under this contract. This equipment will require energy of 3-phase, 60-cycle for operation and the voltage shall be as required for each specified use. The contractor shall maintain service until completion of the contract. All costs for electrical energy shall be borne by the contractor. The contractor shall make payment to the Government each month for electrical energy furnished him, at the rate of the actual cost to the Government, plus 10% to cover installation and overhead, for supplying the electrical energy. This rate will be in accordance with service classification No. 2-A of the Central New York Power Corporation.

(b) The Contractor shall provide for the period of this contract the electrical energy for lighting and miscellaneous use in the government field office (Section XVI). The contractor shall provide an electric meter in the field office, and each month the electrical energy furnished the field office will be deducted from the total electrical energy furnished the contractor. The energy furnished the field office shall be 220/110-volt, 60-cycle, single-phase, 3 wires.

1-12. ORDER OF WORK. - The following general program of work is contemplated, subject to such modifications as may be found necessary or desirable by the contracting officer. The main features of work are as follows:

(a) Construction of cofferdams "A", and "B", and "C" and unwatering.

(b) Construction of the substructure of the powerhouse, especially the forebay section complete, ready to place the stoplogs or gates before date of raising the pool.

(c) Construction of the concrete wing dams and the forebay dike on Barnhart Island.

(d) The construction of the forebay dike on the Canadian side can not be started until the new Cornwall Canal and lock are complete and traffic switched to the new canal, then the dike must be completed as shown on the drawings before the date of raising the pool.

(e) The completion of all remaining work under this contract.

(f) The contractor shall at all times keep the contracting officer informed of the order of proposed operations. To this end, in addition to the charts required to be submitted in accordance with paragraph 16 (d) of the Invitation for Bids, the contractor shall furnish such supplementary charts and/or other information regarding proposed future operations as may be required by the contracting officer.

1-13. RIGHT-OF-WAY. - The right-of-way for the work covered by these specifications and for the access railroad and highway will be furnished by the Government.

1-14. ROADS AND GROUNDS.

(a) The contractor will have the privilege of using the Government-controlled land within the work areas shown on Sheet No. 2 of the drawings except for that part of said lands as may be reserved by the contracting officer for other purposes.

(b) At any time during the progress of the work the contractor

shall, when so directed by the contracting officer, promptly vacate and clean up, within 60 days after written notice, without expense to the Government, any part of the grounds which have been in use by him when such grounds are needed for other purposes. The contractor shall keep the buildings and grounds in use by him at the site of the work in an orderly and sanitary condition and shall provide suitable extinguishers or other fire-fighting apparatus for ready use in all buildings erected or in use by the contractor on Government property.

(c) A temporary single lane roadway and single track railroad to be constructed by others will provide access from the New York mainland to the westerly end of Barnhart Island. The temporary road and railroad is expected to be ready about 18 months after the start of work on this contract, and will connect with the access highway and railroad which is part of this contract. (See Section ____).

(d) The contractor shall not obstruct any existing roads on the lands controlled by the United States and shall maintain all roads in the vicinity of the work in as good condition as exists at the time of commencement of the work.

(e) The contractor will be required to construct a covered wooden observation platform having an area of about six-hundred (600) square feet for the use of the general public. This platform shall be constructed at a location selected by the contracting officer. The contractor shall also provide suitable and safe access to the observation platform for the general public so that it may observe the work in progress. No separate payment will be made for this work.

1-15. CAMP CONSTRUCTION AND SUPERVISON.

(a) The construction, operation and maintenance of facilities for the quartering and subsisting of the contractor's employees will be subject to the approval of the contracting officer if the facilities are located on Government property. The contractor will be permitted to construct such facilities on the right-of-way owned by the Government only at such location specifically approved by the contracting officer. The type of construction and design for the buildings erected by the contractor will be subject to the approval of the contracting officer. Expensive or permanent types of construction will not be required, but no unslightly, unsanitary shacks or shanties will be permitted. The contractor will be required to comply with State and local laws relative to police and sanitary measures and with other protective measure imposed by the contracting officer in the administration of his camps. In the event of noncompliance with such laws and regulations, the contracting officer will enforce them at the expense of the contractor. The contracting officer may require the contractor to discharge any employee from the work for violation of camp regulations. (See paragraph 1-21 (c).)

(b) In the event the contractor makes arrangements withland-owners, other then the Government, near the site of work for the construction of temporary facilities for the quartering and subsisting of his employees, he will be subject, in the operation and maintenance of such a camp, to all the provisions of subparagraph (a) above with respect to the requirements for compliance with all State and local laws relative to police and sanitary measures, and with measures such as safety, fire hazard and protection, etc., imposed by the contracting officer. In the event of noncompliance with such laws and regulations while operating and maintaining a temporary camp not on the Government-owned or controlled property, the contracting officer will enforce them at the expense of the contractor.

The contracting officer may require the contractor to discharge from the work any employee for violation of camp regulations, notwithstanding the fact that the camp may not be located on Government-owned or controlled property.

(c) In the event the contractor provides subsistence for his employees, he shall also provide subsistence to such Government employees as may require such accommodations and at the same rates charged his own employees.

(d) No business or recreational facilities shall be established or operated on Government-owned or controlled lands without the written approval of the contracting officer.

1-16. BORROW PITS.

(a) Should the contractor locate deposits of bank run sand and gravel or other materials within the Government-controlled area in the reservoir or adjacent to the site, which are satisfactory to the contracting officer, he may, on approval of the contracting officer use such deposits. No charge will be made to the contractor for materials authorized to be taken from Government-controlled lands and used in the work covered by these specifications. All borrow pits shall be left in a neat and sightly condition, and all pits above the normal ground water table shall be adequately drained. Side slopes shall be not steeper than 1 on 3. No separate payment will be made for such work.

(b) Approval of material sources by the contracting officer shall not constitute approval of all materials taken from such deposit and the contractor will be responsible for the quality of all material used in the work.

(c) Should the contractor obtain materials from deposits on private lands he shall pay any royalities or other charges required, and the contracting officer assumes no responsibility for such use, and the Government will not be obligated in any way.

1-17. DATUM AND REFERENCE BENCH MARKS. - The plane of reference used in these specifications and on the drawings is Mean Sea Level. Elevations refering to this datum plane are to be determined from the following bench mark; See Bulletin 514, Results of Spirit Leveling in New York. U. S. Geological Survey, page 59.

Pollys Creek, 420 feet east of, 5.5 feet from south fence of road, on south side of river road on line of a stone fence running north and south, opposite barnyard of Frank Polly's farm; top of roundheaded brass bolt set in concrete base (U. S. Corps of Engineers 4). Elevation 221.378.

1-18. PHYSICAL DATA.

(a) Foundation data. - Investigations, including surveys, borings, test trenches, pits and test shafts made at the site by the United States to determine the character of the foundation materials are shown on the drawings referred to in paragraph 1-04.

The United States does not guarantee that other materials will not be encountered nor that the proportions of the several materials will not vary from those indicated by the explorations. Bidders are expected to examine the site of the work, the logs of borings, test pits, probings, and the cores and samples which are available at the U. S. Engineer Officer,

Massena, New York, and, after investigations, decide for themselves the character of the materials and make their bids accordingly.

(b) Weather Conditions. - Meteorological data in the form of rainfall and temperature records, prepared from records covering a period of 33 years (1907 to 1939, inclusive), of the U. S. Weather Bureau Station at Canton, New York, approximately 35 miles southwest of the site of the work, are as follows:

	Temperature Degrees Fahrenheit		Precipitation (Mean Monthly)	
Month	Mean Monthly	Extreme Max.	Extreme Min.	Total Inches	Inches of Snow
January	16.8	61	-41	2.64	14.9
February	15.8	63	-43	2.30	15.5
March	27.9	78	-30	2.60	13.1
April	41.7	85	-1	2.59	4.9
May	54.2	93	21	3.03	0.2
June	63.5	97	30	3.51	0
July	68.8	99	34	3.62	0
August	66.5	96	35	3.42	0
September	58.8	91	25	3.44	0.1
October	47.4	83	14	3.04	1.0
November	35.0	75	-15	3.02	7.5
December	21.4	61	-37	2.62	14.5

(c) St. Lawrence River Water Temperature. - The St. Lawrence River water temperatures prepared from records covering a period of 8 years (1933 to 1940, inclusive) of the City Engineer, Ogdensburg, New York, are as follows:

	Water Temperature Degrees Fahrenheit		
Month	Mean Monthly	Extreme Max.	Extreme Min.
January	32.7	36	32
February	32.9	37	32
March	33.0	37	32
April	36.2	46	32
May	46.9	60	37
June	58.8	66	49
July	65.5	73	59
August	70.5	74	63
September	64.6	72	59
October	56.4	65	50
November	46.5	52	37
December	35.7	44	32

The above data are included for the information of the contractor. The Government assumes no responsibility for their completeness or accuracy or for deductions, interpretations, or conclusions drawn therefrom.

(d) River Stages. - Mean low water of the St. Lawrence River at the foot of Barnhart Island is at Elevation 158.6. During the period of

record of winter water surface elevations, 1913 to 1940, inclusive, the maximum stage occurring at this point during the winter months of December-March, inclusive, is estimated to have been Elevation 196.2 (Jan. 1918). Winter stages frequently have reached levels between El. 175 and El. 190. Such high stages are produced by ice conditions in the river downstream from the site of the work and are not expected to occur during the period April 16 to Nov .30. The maximum stage occurring at the aforementioned location from 1860 to 1940 inclusive during the period April 16 to Nov. 30, is estimated to have reached approximate Elevation 162.6. Additional data on river stages are available for inspection in the U. S. Engineer Office, Massena, N. Y. The Government does not guarantee the completeness or accuracy of any of the above data and assumes no responsibility for deductions, interpretations, or conclusions drawn therefrom.

(e) Utilities. - In the event that power lines, telephone or telegraph lines, pipe lines, cables, or other utilities are encountered within the limits of the work including the access right-of-way, the contractor shall notify the contracting officer in writing of any necessary changes in such utilities not less than 30 days in advance of the date he desires such changes made. The contracting officer will arrange for the relocation or reconstruction of such utilities by other agencies, or will authorize the contractor to remove them, at no extra cost to the Government, to the extent required for execution of the contract work.

1-19. TRANSPORTATION FACILITIES. - The following data on transportation facilities is furnished for the information of the contractor but the Government assumes no responsibility for its completeness or accuracy and the contractor is expected to investigate the conditions and determine for himself the probable transportation facilities available.

(a) Railroads. - At the present time the nearest rail facilities are the New York Central Railroad connections with Massena, N. Y. and Canadian National Railroad connects with Cornwall, Ontario, Canada. As shown on the plans a railroad connection will be built by others prior to this contract connecting the Canadian National and New York Central and Ottawa Branch in Canada to the power house site.

(b) Highways. - On the Canadian side, Kings Highway No. 2 passes near the site, and an access highway will be built by others as indicated on the drawings prior to this contract.

On the United States side, the village of Massena is served by New York State Highways No. 37, No. 56, and No. 420. U. S. Highway No. 11 passes through Potsdam, about 21 miles from Massena via N. Y. Highway No. 420. Several improved town or county roads connect the aforementioned State Highways to points on the south side of the river opposite the site. A crossing will be provided later at Long Sault Dam. (See paragraph 1-14 (c)).

(c) Water. - The nearest port to the site of the work providing docking and other harbor facilities is Cornwall, Ontario, Canada. Cornwall is accessible by water from Lake Ontario and from the head of deep-water navigation at Montreal by means of the St. Lawrence Canals and open-river stretches of navigable channels. Locks in the canals generally limit the size of craft to widths less than 45 feet, lengths less than 250 feet, and drafts less than 14 feet. For a detailed description of the existing canal and lock clearances and depths, the contractor is referred to the booklet "The Canals of Canada", published by the Department of Transport, Ottawa, Ontario, Canada, copies of which are available for inspection in the U. S. Engineer Office, Massena, N. Y. The navigation season is usually limited by ice conditions to the period from April 20 to December 1.

1-20. ORGANIZATION, PLANT AND PROGRESS.

(a) The contractor shall perform, directly and without subcontraction, not less than fifty percent (50%) of the work, to be calculated on the basis of the contract price.

(b) The contractor shall employ an ample force of properly experienced men and provide a construction plant properly adapted to the work and of sufficient capacity and efficiency to accomplish the work in a safe and workmanlike manner at the rate of progress specified in his bid. All plants shall be maintained in good working order and provision shall be made for immediate emergency repairs. No reduction in the capacity of the plant employed on the work shall be made except by written permission of the contracting officer. The measure of the "capacity of the plant" shall be its actual performance on the work to which these specifications apply. It is understood that award of this contract shall not be construed as a guaranty by the United States that plant listed in statement of contractor for use on this contract is adequate for the performance of the work.

(c) Should the contractor fail to maintain the rate of progress proposed in his bid, the contracting officer may require that additional men or plant, or both, be placed on the work, working if necessary during additional periods, or a reorganization of plant layout be effected in order that work be brought up to schedule and maintained there. Should the contractor refuse or neglect so to increase the number of men or plant, or both, or to reorganize the plant layout in a manner satisfactory to the contracting officer, the latter may proceed under the provisions of Article 9 of the contract.

1-21. LIABILITY AND SAFETY REQUIREMENTS.

(a) Accident Prevention. - In order to protect the life and health of employees in the performance of this contract, the contractor will comply with all pertinent provisions of the "Safety Requirements in Excavation - Building - Construction" approved by the Chief of Engineers, December 16, 1941, (a copy of which is on file in the office of the contracting officer) and as may be amended, and will take or cause to be taken such additional measures as the contracting officer may determine to be reasonably necessary for this purpose. The contractor will maintain an accurate record of and will report to the contracting officer in the manner and on the forms prescribed by the contracting officer, all cases of death, occupational disease and traumatic injury arising out of or in the course of employment on work under this contract. The contracting officer will notify the contractor of any non-compliance with the foregoing provisions and the action to be taken. The contractor shall, after receipt of such notice, immediately correct the conditions to which attention has been directed. Such notice, when served on the contractor or his representative at the site of the work, shall be deemed sufficient for the purpose aforesaid. If the contractor fails or refuses to comply promptly, the contracting officer may issue an order stopping all or any part of the work. When satisfactory corrective action is taken, a start order will be issued. No part of the time lost due to any such stop order shall be made the subject of claim for extension of time or for excess costs or damages by the contractor.

(b) The contractor will not be allowed to block or obstruct any public highway without having secured prior permission from the contracting officer, and he shall provide safe, temporary detours. During the time the public highways may be so blocked, the contractor shall place danger

lights, barricades and warning signs in accordance with all applicable laws and regulations.

(c) The contractor shall be responsible that his employees strictly observe all applicable laws and regulations affecting all operations at the site under the contract. He shall comply with all applicable Federal, State and local laws and regulations including those concerning the inspection of boilers and other equipment, the licensing of engineers and other employees.

(d) The United States will not be responsible for any damage to or increased difficulties in performance of the work under this contract on account of any scour or other changes in the river bed or banks or water currents resulting from other construction at the site, and no payments, allowances or deductions will be made for or on account of any such damage or difficulties.

(e) Nothing in this paragraph shall be construed as modifying the responsibility of the contractor as set forth in Article 10 of the contract.

1-22. LIGHTS. - The contractor shall, at his own expense, display proper lights continuously each night, between the hours of sunset and sunrise and during fogs, upon cofferdams, all floating plant connected with the work, and all ranges and other stakes in connection with it, when necessary in the opinion of the contracting officer, and shall be responsible for all damages resulting from any neglect or failure in this respect. If work is done at night the contractor shall maintain, from sunset to sunrise, such lights on or about his plant as the contracting officer may deem necessary for the proper observation of the operations.

1-23. USE OF EXPLOSIVES. - The contractor shall use the utmost care in the use of explosives necessary for the prosecution of the work, not to endanger life or property. All blasting operations shall be conducted by experienced men only. The handling anduse of explosives shall be done strictly in accordance with the specifications issued by the U. S. Bureau of Mines, and all applicable laws and regulations. Failure to observe necessary precautions will be sufficient grounds for temporary suspension of the work. All explosives shall be transported and stored in a secure manner, and in accordance with local and State laws: all vehicles and such storage places shall be marked clearly "DANGER-EXPLOSIVES", and shall be in the care of competent watchmen at all times. In no case shall caps or other detonators be stored or transported with dynamite or other explosives. The location of magazines for the storage of explosives and for the separate storage of detonators shall be subject to the approval of the contracting officer.

1-24. PROPERTY DAMAGE.

(a) Damage to Government property or to the works due to failure of the contractor to carry out the terms of the contract and specifications, to take reasonable precautions, or to maintain progress to approved schedules, or to carry out the instructions of the contracting officer shall be made good by the contractor without expense to the United States. He will also be held responsible for any damage done to adjoining property through his neglect or failure to take proper precautions (See Article 10 of the contract).

(b) The contractor will not be held responsible for damage sustained by the permanent work from accident, flood, or exposure where such damage is not due to his fault or negligence and where the work is being conducted in accordance with the terms and schedule of the contract and specifications, but he shall make such repairs as the contracting officer may direct to such damaged portions of the work, at the applicable contract unit prices for the various items of work.

1-25. INSPECTION.

(a) The work will be conducted under the general direction of the contracting officer and will be inspected in accordance with Article 6 of the contract by inspectors appointed by him. The inspectors will keep a record of the work done and see that the location and limit marks are kept in proper order, but the presence of the inspector shall not relieve the contractor or his responsible agent (see Article 8 of the contract of responsibility for the proper execution of the work.

(b) Should the contractor refuse, neglect or delay compliance with the requirements concerning facilities for inspection and layout (see paragraph 1-26), the specific facilities may be furnished and maintained by the contracting officer, and the cost thereof deducted from any amounts due or to become due the contractor.

(c) Except as specified in this paragraph, in Article 6 of the contract, and in paragraphs 1-31 (d) and 1-26, all expenses of inspection will be borne by the United States.

(d) It is understood that any instructions, or decisions given by a superior officer, through the contracting officer, are to be considered instructions or decisions of the contracting officer, in all cases where, under the terms of this contract, decision rests with the contracting officer.

(e) The contractor shall furnish a suitable room containing at least 150 square feet of floor space, at each of his concrete mixing plants for a Government laboratory to be used for temporary storage of concrete cylinders, and determination of moisture content of the concrete aggregate. This room shall be protected from the weather, properly lighted, provided with necessary work tables and benches, and shall be heated if concrete work is done in cold weather. The location for this room shall be subject to the approval of the contracting officer. The contractor shall provide, during the construction period, electricity for light and miscellaneous uses, see paragraph 1-11 (b), and an adequate supply of water for drinking and sanitary purposes in the Government field office, constructed in accordance with Section XII of these specifications.

(f) Portable Building. - The contractor shall furnish two suitable portable buildings, located as required by the contracting officer within the site of the work, for use by the Government. These buildings shall be approximately 10 feet by 12 feet and shall be supplied with an instrument rack, a built-in desk, clothes lockers, supply cabinet with lock, bench and such other appurtenances as may be required by the contracting officer. The buildings may be of any type construction as approved by the contracting officer and shall be movable, as the contracting officer may require them to be shifted during progress of the work. They shall be reasonably weather proof, and shall be supplied with heat and electric lights without cost to the Government.

1-26. LINES,GRADES AND MEASUREMENTS.

(a) The work shall be carried out in strict accordance with lines, grades, and dimensions shown on the drawings or as directed from time to time by the contracting officer.

(b) The contractor shall, at his own expense, furnish all stakes, templates, patterns, platforms and special labor that may be required in setting and cutting, or laying out any part of the work.

(c) The contracting officer will furnish the control points, lines, grades, and elevations necessary to enable the contractor to perform the construction work. After this layout has been made by the contracting officer, it shall be the responsibility of the contractor to supply and maintain all additional survey points, grade stakes, form locations and other work lines necessary for the proper execution and conduct of the work. From time to time during the progress of the work, the contracting officer will check the contractor's lines and grades to determine whether or not the work is being accurately and properly executed, but such checks will in no way relieve the contractor of the responsibility for executing the work in accordance with the plans and specifications, and the original field layout furnished by the contracting officer.

(d) Bench marks, triangulation stations,and principal control points shall be preserved by the contractor and in case of their destruction or removal by him or his employees, they will be replaced by the contracting officer at the contractor's expense.

1-27. CHANGES AND CHANGED CONDITIONS. - When changes are made in the specifications or drawings, or changed conditions are encountered during the progress of the work, which cause an increase or decrease in the amount due under the contract, or in the time required for its performance, an equitable adjustment shall be made in accordance with Articles 3 and 4 of the contract.

1-28. MINOR MODIFICATIONS.- The right is reserved to make such minor changes in the execution of the work to be done under these specifications as, in the judgment of the contracting officer, may be necessary or expedient to carry out the intent of the contract; provided, that the unit cost to the contractor of doing the work shall not be increased thereby, and no increase in unit price over the contract rate will be paid to the contractor on account of such changes. (See Articles 3,4, and 5 of the contract).

1-29. CLAIMS PROTESTS AND APPEALS

(a) If the contractor considers any work demanded of him to be outside the requirements of the contract or if he considers any action or ruling of the contracting officer or of the inspectors to be unfair, the contractor shall without undue delay, upon such demand, action, or ruling, submit his protest thereto in writing to the contracting officer, stating clearly and in detail the basis of his objections. The contracting officer shall thereupon promptly investigate the complaint and furnish the contractor his decision, in writing, thereon. If the contractor is not satisfied with the decision of the contracting officer, he may, within thirty days, appeal in writing to the Secretary of War, whose decision or that of his duly authorized representative shall be final and binding upon the parties to the contract. Except for such protests or objections as are made of record in the manner herein specified and within the time limit stated, the record, rulings, instructions or decisions of the contract-

ing officer shall be final and conclusive.

(b) All appeals from decisions of the contracting officer authorized under the contract shall be addressed to the Secretary of War, Washington, D. C. The appeal shall contain all the facts or circumstances upon which the contractor bases his claim for relief and should be presented to the contracting officer for transmittal within the time provided therefor in the contract.

1-30. PATENTS. - The contractor shall hold and save the Government, its officers, agents, servants and employees, harmless from liability of any nature or kind, including costs and expenses for or on account of any patented or unpatented invention, article or appliance manufactured or used in the performance of this contract, including its use by the Government.

1-31. STANDARD TESTS, QUALITY AND GUARANTEES.

(a) All materials furnished by the contractor, supplies and parts, and assemblies thereof, entering into the work to be done under these specifications, shall be tested as specified herein, or if not specified, in conformity with Article 6 of the contract and according to the best modern approved methods for the particular type and class of work.

(b) Unless other wise authorized or directed, where standard published specifications of recognized authorities or organizations are specified, the latest revision of such specifications current at the time the work is executed shall govern.

(c) Unless waived in writing by the contracting officer, all tests and trials shall be made in the presence of a duly authorized representative of the contracting officer. When the presence of the inspector is so waived, sworn statments, in triplicate, of the tests made and the results thereof, shall be furnished the contracting officer by the contractor as soon as possible after the tests are made.

(d) All costs of all tests and trials, excepting the expenses of the Government inspector, shall be borne by the contractor and shall be included in the contract price, unless specified otherwise.

(e) In accordance with Article 7 of the contract, all materials, supplies and articles furnished and incorporated in the permanent structure shall be of the highest grade, free from defects and imperfections, of recent manufacture, and unused. Workmanship shall be of the highest grade and in accordance with the best modern standard practice.

(f) All articles, supplies, equipment, parts and assemblies thereof, of standard manufacture, or for which detail design or requirements are not prescribed in these specifications shall be guaranteed by the contractor against any failure in proper use or operation, caused by defective material, workmanship or design, for a period of one year from the date of final acceptance of the complete work under this contract. Failure in any part due to such causes within that time shall be promptly and satisfactorily remedied by the contractor without cost to the United States.

1-32. PROTECTION OF STORED MATERIALS. - All materials, supplies and articles delivered at the site shall be adequately housed or otherwise protected against deterioration and damage to the satisfaction of the contracting officer. When material stored at the site and partly paid for is not adequately protected by the contractor, such material will be kept protected by the contracting officer at the expense of the contractor, and

no partial payments will be made upon future delivery of the articles or commodities in question.

1-33. MISPLACED MATERIAL. - Any material that is deposited elsewhere than the place designated or approved by the contracting officer will not be paid for, and the contractor may be required to remove such material and waste it or redeposit it as directed.

1-34. STANDARD STOCK PRODUCTS.

(a) All materials, supplies and articles furnished shall, wherever so specified, and otherwise wherever practicable, be the standard stock products of recognized reputable manufacturers. The standard stock products of manufacturers other than those specified will be accepted when it is proved to the satisfaction of the contracting officer that they are equal in strength, durability, usefulness and convenience for the purpose intended (see Article 7 of the contract). Any changes required in the details and dimensions shown on the drawings for the substitution of standard stock products, other than those provided for, shall be properly made as approved by the contracting officer, and at the expense of the contractor. The references herein to brands and catalog numbers are intended to be descriptive and not restrictive, and are used only to indicate articles that will be satisfactory. Other makes and catalog numbers will be accepted provided that they are similar and equal to those specified herein or called for on the drawings.

(b) Date to be Submitted for Approval. In accordance with Article 7 of the contract, prior to the placing of any purchase order for products of standard manufacture, and sufficiently in advance of the proposed purchase date to enable the contracting officer to determine whether the proposed product conforms to the specifications, the contractor shall submit for the approval of the contracting officer complete descriptive data in triplicate, consisting of dimensioned drawings, catalog references and specifications, typical performance records, and such other information as may be required to be submitted on special forms to be furnished by the contracting officer to identify clearly each product in question. The term "or equal" shall not be used in any descriptive information furnished. Except at the contractor's risk no purchase order shall be placed for any product which has not been approved by the contracting officer.

(c) Final Completion Data.- There shall be supplied 5 complete sets of data, each separately bound in a leather binder, for each major item of equipment furnished and installed under this contract. These data shall consist of all necessary instruction bulletins, complete drawings, complete parts and material lists positively identifying each part, manufacturer's recommendation as to spare parts, and all other necessary data.

1-35. PREFERENCE FOR DOMESTIC ARTICLES.

(a) With reference to article 18 of the contract, because the materials listed below, or the materials from which they are manufactured, are not mined, produced, or manufactured, as the case may be, in the United States in sufficient and reasonable available commercial quantities and of a satisfactory quality, their use in the work herein specified is authorized without regard to the country of origin;

Platinum	Nickel	Asbestos
Chromium	Rubber	China Wood Oil (Tung Oil)
Cork	Teak Wood	Balsa Wood
Jute	Silk	English Ball Clay
Kaurigum	Sisal	English China Clay
Lac	Tin	Natural Copper-Nickel
Asphalt	Aluminum	Alloy
		Diamonds

(b) Articles, materials or supplies manufactured in the United States and containing mercury, antimony, tungsten or mica of foreign origin may be used in the work herein specified because such manufactured articles, materials, or supplies have been manufactered in the United States substantially all from articles, materials, or supplies, mined, produced or manufactured, as the case may be, in the United States.

1-36. INTERFERENCE WITH OTHER CONTRACTORS. - Other contractors will perform work on the Barnhart Island Power House pertaining to installing and placing electrical equipment, and operating equipment and finishing interior of powerhouse. In addition other major work will be undertaken in the vicinity of the power house at approximately the same time, such as the Cornwall Canal and lock and the Long Sault Dam. The contractor shall not interfere with material, appliances or workmen of the United States or of any other contractor who may have work at this site. The contractor for the construction of Long Sault Dam will have a right-of-way for access to the site of his work at the westerly end of Barnhart Island, and will have the right to build, maintainand use a road and railroad on said right of way for that purpose, and this contractor shall not interfere with his use of said right-of-way. The use of said right-of-way by the contractor for Long Sault Dam will terminate after canal traffic has been diverted to the new Cornwall Canal and when it becomes necessary for this contractor to commence work on the north forebay dike. The location and width of said right-of-way past the north end of the powerhouse, across cofferdam B, and thence to the access railroad and highway on Barnhart Island, will be as shown on the drawings. As far as practicable, all contractors shall have equal rights to the use of all roads, ground, and adjacent river, and make equitable agreements among themselves for the use of temporary railroads and highways. In case of disagreement regarding such use, the decision of the contracting officer shall govern. (See Article 13 of the contract).

1-37. RESTORATION OF SITE. - Before final payment is made, the contractor shall remove from the site, without expense to the United States, all rubbish and unused materials provided by him, temporary buildings, cofferdams and other structures erected by him, shall fill all holes or cavities made for his convenience, except as otherwise provided, and shall leave the whole site in good order and condition, all as required by the contracting officer.

1-38. WAGE AND LABOR PROVISIONS.

(a) Pursuant to the provisions of Article 17 of revised United States Standard Form No. 23 the following wage rates have been determined by the Department of Labor:

SCHEDULE OF WAGE RATES

Classification	Minimum Rate per Hour
Blacksmith	
Blacksmith Helper	
Boilermaker	
Boilermaker Helper	
Bricklayer	
Bricklayer Tender	
Carpenter (Skilled)	
Carpenter, Apprentice, 1st year	
Carpenter, Apprentice, 2nd year	
Carpenter, Apprentice, 3rd year	
Concrete Finisher (Rough concrete)	
Concrete Form Stripper	
Concreteman (Puddler, Screeder, Vibratorman & Curing)	
Conveyor Tender	
Dumpman (Spotter & Grademan)	
Electrician	
Electrician Helper	
Engineman (Stationary Power Plants)	
Fireman	
Glazier	
Hooktender (Concrete Placement)	
Laborer (Common)	
Machinist	
Machinist Helper	
Mason (Stone)	
Mechanic	
Mechanic Helper	
Millwright	
Motorman (Dinky)	
Oiler	
Operators of Power Equipment:	
Air Compressor (over 750 c.f.m.)	
Air Compressor (750 c.f.m. and under)	
Air Hammer (Jackhammer, Pavement Breaker, etc.)	
Cement Pump	
Concrete Batching Plant	
Concrete Mixer	
Concrete Pump	
Core Drill	
Crane (except Gantry Crane)	
Derrick	
Dragline	
Elevating Grader	
Gantry Crane	
Grader (Finish)	
Grader (Rough)	
Grout Machine	
Hoist	
Launch Operator (150 H.P. or under)	
Pile Driver	
Power Saw	

SCHEDULE OF WAGE RATES (CONTINUED)

Classification	Minimum Rate per Hour
Power Scraper	
Pump (100 H.P. or over)	
Pump (under 100 H.P.)	
Screening Plant	
Shovel	
Tractor (Under 35 H.P. without attachments)	
Tractor (35 H.P. and over, and all tractors with attachments)	
Painter	
Pile Drivermen, Leadsmen, Linesmen, Nozzelemen, Winchmen	
Pipe Fitter	
Pipe Fitter Helper	
Plasterer	
Plasterer Tender	
Plumber	
Plumber Helper	
Powderman	
Powderman Helper	
Reinforcing Steel Worker	
Rigger	
Roofer	
Sheetmetal Worker	
Signalman, Concrete Placement (Phone man)	
Structural Steel Worker	
Structural Steel Worker Helper	
Teamster (2 up)	
Teamster (4 up or more	
Tool Dresser	
Truck Driver (under 4 tons)	
Truck Driver (4 tons to 10 tons)	
Truck Driver (over 10 tons)	
Welder (Certified - structural steel)	
Welder (Certified - other than structural steel)	
Welder's Helper	

(b) Each class of laborer and mechanic specified in the above schedule shall receive not less than the minimum rate of wages specified therein, except that deductions from wages paid may be made as required by any laws now or hereinafter in force, in the state in which this project is situated, calling for contributions by employees from earnings to funds maintained in the administration of an unemployment compensation law under the Social Security Act. In the event that it becomes necessary to employ and laborer or mechanic whose work is not covered by any of the classifications in said schedule, he shall be paid not less than the prevailing rate of wages for the class of work done by him. Such rate shall be predetermined by the contracting officer. In case any dispute arises as to what are the prevailing rates of wages for work of a similar nature which cannot be adjusted by the contracting officer, the matter shall be referred to the Secretary of Labor for determination and his decision thereon shall be conclusive on all parties thereto.

(c) The contractor will be required to furnish identification badges for all his employees. These badges shall show the employee's photograph, printed name, and signature, and shall be of a design approved by the contracting officer.

(d) The contractor, in performing the work required by this contract, shall not discriminate against any worker because of race, creed, color or national origin.

(e) The contractor agrees that the provisions of paragraph (d) above will also be inserted in all of his subcontracts. For the purpose of this article a subcontract is defined as any contract entered into by the contractor with any individual, partnership, association, corporation, estate, or trust or other business enterprise or legal entity, which involves performance, wholly or in part at the site of the work, of some part of the work to be performed under this contract.

1-39. REPORTS TO DEPARTMENT OF LABOR. - The contractor shall report monthly, and shall cause all subcontractors to report in like manner, within five days after the close of each calendar month, on forms to be furnished by the Department of Labor, the number of persons on their respective payrolls, the aggregate amount of such payrolls, the man hours worked, and the total expenditures for materials. He shall furnish to the Department of Labor the names and address of all subcontractors on the work at the earliest date practicable, provided that the foregoing shall be applicable only to work at the site of the construction project. Copies of all data furnished the Department of Labor shall be promptly furnished the contracting officer.

1-40. INVOICES. - The contractor shall furnish the contracting officer with copies of all invoices for the purchase of materials, supplies and plant in connection with the work to be performed under these specifications. The contractor's records shall be subject to inspection by the contracting officer to verify the accuracy and completeness of the information furnished.

1-41. COST DATA. - The Government will keep a record of the costs of the work performed under these specifications and the contractor shall permit the contracting officer to have access to his timekeeping, invoices and plant records for this purpose. The contractor shall also furnish the contracting officer with a statement of the initial cost and date of purchase of all plant used in connection with the work.

1-42. ADJUSTMENT OF CONTRACT PRICE BY REASON OF CHANGE IN FEDERAL, STATE OR LOCAL TAXES. - The contract price will be considered to include all Federal, State and local taxes imposed prior to the date of opening bids and applicable to the undertaking. If any privilege, sales, gross receipts or other tax (exclusive of taxes on net income or undistributed profits), applicable to the undertaking and payable directly by the contractor, is imposed or changed after the date of opening bids by Federal or State enactment, then the contract price will be increased or decreased accordingly and any amount due or chargeable against the contractor as a result thereof will be adjusted on payment vouchers as separate items.

1-43. SUBCONTRACTORS. - Subcontractors and their employees shall be considered to be employees of the contractor as the term "employee" is

used in these specifications.

1-44. SITE OF WORK. - The term "Site of the Work", as used in these specifications and in Articles 17 and 19 of the contract, will embrace all areas wherein field operations are conducted by the contractor in connection with this contract, including work areas, shops, yards, camps, etc., irrespective of whether such operating areas lie within the limits of work areas or rights-of-way shown on the drawings.

1-45. ASSIGNMENT OF CLAIMS. - The Act of October 9, 1940 (Public No. 811, 76th Congress) provides that Sections 3477 and 3737, Revised Statutes, shall not apply to any case in which the moneys due or to become due from the United States, under a contract providing for payments aggregating $1,000 or more, are assigned to a bank, trust company, or other financing institution, including any Federal lending agency. An assignment may be made under this contract, pursuant to the Act of October 9, 1940, cited above, and subject to the further provision stated below:

(a) Any assignment shall cover all amounts payable under this contract and not already paid and shall not be made to more than one party, except that any such assignment may be made to one party as agent or trustee for two or more parties participating in such financing.

(b) Any claim under this contract which may be assigned may be subject to further assignment to a bank, trust company, or other financing institution, including any Federal lending agency, and to similar further assignment; provided, that any such assignee shall file written notice of the further assignment together with a true copy of the instrument of further assignment with the contractor and also as provided in proviso 4 of section 1 of the Assignment of Claims Act of 1940 (Public No. 811, 76th Congress) in respect to original assignment.

(c) No assignee shall divulge any information concerning the contract, or contained therein, except to those persons necessarily concerned with the transaction.

(d) Payments to an assignee of any claim arising under this contract shall not be subject to reduction or set off for any indebtedness of the assignor to the United States arising independently of this contract.

1-46. ADJUSTMENT OF PRICES FOR LABOR AND MATERIALS.

(a) The following terms used hereafter are defined as follows:

(1) "Basic hourly earnings index" shall be determined by adding monthly average hourly earnings in the "_____" industry as indicated under heading "_____ " in the monthly pamphlet "Hourly Wages and Labor Employment" issued by the Department of Labor for: the month in which contract time commences, the five (5) months preceding such month, and the six (6) months succeeding such month; and then dividing this total by twelve (12).

(2) "Basic materials index" shall be determined by method in (1) above, using monthly indices for item " _____ " in the monthly pamphlet "Wholesale Prices" issued by the Department of Labor.

(3) "Monthly labor adjustment index" shall be determined from monthly average hourly earnings identified as to source in (1) above as follows: Add the average hourly earnings for the month for which adjustment is being made, the two preceding months and the two succeeding months; and then divide this total by five (5).

(4) "Monthly materials adjustment index" shall be deter-

mined by method in (3) above, using monthly indices identified as to source in (2) above.

(5) Above contract indices in (1), (2), (3), and (4) shall be computed to nearest second decimal place, taking the decimal point as located in indices issued by the Department of Labor. When third decimal place computes to 5 or over, the figure in second decimal place shall be raised to next higher figure.

(b) (1) The proportion of the contract price represented by labor, subject to adjustment in price, is accepted as _____ per cent of the contract price.

(2) The proportion of the contract price represented by materials, subject to adjustment in price, is accepted as _____ per cent of the contract price.

(c) (1) The labor cost for entire contract as determine in (b) (1) above shall within thirty (30) days after receipt of notice to proceed, be divided into monthly labor cost quotas, prepared by the contractor and subject to the approval of the contracting officer, for each partial or whole calendar month of the contract time beginning with the notice to proceed.

(2) The materials cost for entire contract as determined in (b) (2) above shall be similarly divided into monthly materials cost quotas within thirty (30) days after receipt of notice to proceed.

(d) Adjustments in payments shall be obtained for each monthly cost quota as follows: - Multiply monthly cost quota by the appropriate monthly adjustment index, divide by corresponding basic index, and subtract monthly cost quota. The result shall be added to or deducted from payments to the contractor.

(e) (1) If the time for performance of this contract is legally extended by the contracting officer, there shall be immediately set up by the contractor, subject to the approval by the contracting officer, new monthly cost quotas as necessary. These new monthly cost quotas may extend back as far as any month for which adjustments in payments have not been completed, but the total of the new quotas shall not exceed the total of the old quotas for which adjustments in payments have not been completed.

(2) If there is an increase or decrease in the work originally contemplated under this contract, there shall be immediately set up by the contractor, subject to the approval of the contracting officer, new monthly costs quotas for months concerned.

(3) If liquidated damages are assessed against the contractor under the contract, such liquidated damages shall not be considered in making adjustments.

(f) The adjustment payment or deduction for any one month shall normally be included with next partial contract payment after receipt of Department of Labor indices for such month.

(g) The acceptance and final payment for work and/or materials under this contract shall be carried out as elsewhere provided in this contract, and amounts retained for the protection of the Government during construction shall be promptly paid upon final acceptance; Provided, however, that an amount, as determined by the contracting officer, for protection of the Government in adjustments not yet completed, shall be retained; and, provided further, that the release required by _____ _____ will contain provision excepting such adjustment payments as may become due the contractor.

(h) After final payment for basic contractual price as indicated in paragraph (g) above has been made, adjustments becoming due will be delayed until all indices necessary for completion of all adjustments under the contract are available, when one lump payment or deduction shall be made for such adjustments.

(i) In case the final adjustment in the contract price results in a net deduction from the contract price, the contractor and his sureties shall be liable for the amount thereof until it is refunded to the Government.

(j) When payment obligations under the contract exceed the contract price as a result of increases in labor and/or materials costs to the extent that available appropriations are exhausted, the Government reserves the right, without further liability to suspend further work under the contract for the account of the Government or to terminate the contract on payment of contractual obligations incurred up to the point of termination.

1-47. FINAL EXAMINATION AND ACCEPTANCE.- When all work called for under this contract has been completed, the contracting officer will make a thorough examination of the same and, if it is found to fully comply with the requirements of the contract, it will be accepted and final payment will be made in accordance with the provisions of Article 16d of the contract.

1-48. APPROVAL. - This contract shall be subject to the written approval of the proper authorities to be designated later and will not be binding until so approved.

SECTION II

DIVERSION AND CARE OF THE RIVER.

2-01. WORK TO BE DONE.

(a) General. - The work under this section includes all required work in connection with handling the flow of the river during the construction period of the entire power house and other structures adjacent thereto including the construction of work in the power house area whether or not such work is a part of this contract. The principal items of the work are:

(1) Construction, maintenance, and removal of cofferdams and other protective structures, including cofferdam sluice gates and their operation.

(2) Unwatering and maintaining working areas free from water.

(b) Scope. - Unless otherwise specified or authorized, all work on construction which forms a part of the permanent structure shall be done in areas free from water. The contractor shall construct, maintain, and remove all cofferdams and diversion structures as directed by the contracting officer, and shall furnish and operate all necessary pumps and other facilities for unwatering and maintaining the various areas of the work free from water as required for construction each part of the work. On completion of the work the contractor shall remove all cofferdams, equipment, and temporary structures, as specified herein or as directed by the contracting officer, dispose of all debris, and restore the work area to a neat and sightly condition. The price bid for each item of the work shall include construction, handling, placing, maintaining, operating, and removing such work unless otherwise specified herein, and the furnishing of all materials, labor, and equipment required therein.

2-02. RESPONSIBILITY.

(a) The contractor shall be responsible for the proper construction, maintenance, operation, and removal of all items of the cofferdams and diversion structures and related services. Any part of the temporary or permanent structures which may fail or be damaged due to negligence on the part of the contractor, and any damage resulting therefrom shall be repaired or replaced, and any required clean-up of debris shall be done, all at the contractor's expense.

(b) The Government will be responsible for the design and adequacy of the cofferdams and diversion structures of the plan specified herein and shown on the drawings (hereinafter designated as the contracting officer's plan). The Government will not be responsible for failure or damage resulting from negligence on the part of the contractor nor for design and adequacy of any alternate cofferdam or diversion plan designed by the contractor. The Government will be responsible as specifically stated for overtopping of a structure where built to the elevation specified.

(c) In the event of failure, including overtopping, of cofferdams or diversion structures where built in accordance with the contracting officer's plan, the contractor shall repair any damage, including clean-up of debris, to any part of the temporary facilities or permanent construction;

Access across cofferdam B shall be available to other interests as directed by the contracting officer (see paragraph 1-36) and the contractor shall at all times maintain the cofferdam so as not to interfere with such access.

(d) Cofferdam C. - Cofferdam C shall be constructed as shown on the plans to elevation 190. It is anticipated that the channel may be initially closed with a structure constructed to elevation 165, and that the remainder of the embankment may be later constructed of material from required excavation. The embankment shall be completed to elevation 190, however, before the danger of high water due to ice gorges arises.

(e) A stop log section shall be provided with a crest elevation of 165, net width of 50 feet, and stop logs to elevation 190. The section under the stop logs shall be composed of rock filled timber cribs sheeted on top and sides so that water may flow over it in either direction without danger to the structure. Steel sheet piling shall be driven along the face of the timber crib section, the top of the piling to be at elevation 165. Stop logs shall be installed in greased timber guides and made watertight. A bridge consisting of timber stringers and floor planking shall be constructed over the stop log openings, as shown on the drawings.

2-06. COFFERDAM CONSTRUCTION.

(a) Timber Cribs. - Timber cribs for the sluiceway in cofferdam C shall be constructed as shown on the plans. The base of each crib shall be shaped, or tailored, in vertical steps equal in height to one horizontal course of timber, to fit the crib foundations as determined by soundings to be made by the Government prior to the construction of the cribs. Timbers shall be fastened by means of drift pins or bolts as shown on the plans. Joints in horizontal courses shall be staggered so that two consecutive joints in a vertical plane shall not occur within the limits of one crib pocket and shall be so placed that a butt joint shall not occur immediately under a cross timber. Butt joints shall be fastened by means of splice blocks as shown on the plans. Holes for drift pins shall be bored with a bit 1/16 inch in diameter less than the thickness of the square pin; holes for bolts shall be bored with a bit equal in diameter to the diameter of the bolts; and holes for tie rods shall be bored with a bit 1/16" in diameter larger than the diameter of the rods. Standard washers shall be used under all bolt heads and nuts which would otherwise come into contact with the wood. Drift pins shall be square in section, square ended and without taper.

(b) Timber Lengths. - Length of timbers will be such that not more than one butt joint will occur in any one horizontal member for cribs exceeding 30 feet in width. For cribs up to and including 30 feet in width, timbers will be furnished in lengths equal to the width of the crib. Timbers for weight pocket flooring will be furnished in standard lengths closest to the length required.

(c) Crib Sheathing. - Certain areas of the cofferdam cribs shall be protected by a double layer of water-tight sheathing, as shown on sheet 12 of the drawings or as otherwise directed by the contracting officer.

(d) Bridge over Sluices. - A bridge shall be constructed over the sluices in the crib cofferdam. The bridge shall be constructed of timber stringers and floor planking as indicated or sheet 12 of the drawings or as directed by the contracting officer.

(e) Steel Sheet Piling. - Steel sheet piling shall have a minimum web thickness of 3/8 inch and shall weigh not less than 31 lbs. per sq. ft. of wall. Piling shall be driven along the face of the timber crib section to form a seal in the river overburden. Piles shall be driven to rock or to refusal and shall be interlocked throughout their length to form a continuous wall. Proper precautions shall be taken to prevent interlock rupture or other injury to the piles; and any pile improperly driven or injured in any manner shall be removed and replaced at the contractor's expense. The top of the piles shall be at elevation 165.

(f) After removal from a cofferdam, steel sheet piling shall remain the property of the contractor, and, if in a satisfactory condition may be re-used by him in another part of the work.

(g) Crib Fill. - Crib fill shall be rock. Fill shall be placed in the weight pockets, at the time of placing the cribs, to trim and sink the cribs. After the cribs are in place all pockets shall be completely filled.

(h) Earth Fill, Cofferdam. - Earth fill in cofferdam embankments shall be Class I, II, and III where shown on the drawings. Class I and II shall conform to the requirements of paragraph 4-04 both as to nature of the material and manner of placing. Class III fill shall be material of the same nature as Class I fill, except that stones need not be removed. Class III fill may be dumped in the water and need not be compacted. Material meeting these specifications is available from the borrow areas indicated.

(i) Rock Fill, Cofferdam. - The function of the rock fill in cofferdams is to form an initial fill to the surface of the water so that the flow will be sufficiently stopped to permit placing earth fill and to stabilize fill placed in the wet. The material may be quarry run rock. It shall be placed to the slopes shown on the plans and to the height of 2 feed above the surface of the water at the time of placing to permit the construction of a roadway.

(j) Riprap, Cofferdam. - Riprap shall conform to the requirements of paragraph 4-08(a)(2).

(k) Drain Pipe, Cofferdam. - Corrugated iron drain pipes conforming to the requirements of paragraph 6-06 shall be placed in cofferdam C as shown on the drawings.

(l) Sand and Gravel Backing. - Sand and gravel backing for cofferdams shall conform to the requirements of paragraph 4-07.

(m) Filter. - Filter for cofferdams shall conform to the requirements of paragraph 4-06.

(n) Cofferdam Removal. - After the work enclosed by the cofferdams has progressed to such extent that the cofferdams are no longer needed, the contractor shall remove cofferdam C to elevation 137 or river bed. Cofferdams A and B will not be removed.

(o) All materials of all kinds used for the construction, maintenance, or repair of cofferdam C shall be completely removed to the specified elevation and disposed of without the use of explosives or the scouring action of the stream and no material shall be permitted to float or wash down the channel. Earth and rock shall be deposited in the spoil areas shown on the drawings and no payment for haul or overhaul of material to such areas shall be made.

2-07. UNWATERING. -

(a) Pumping. - The contractor shall unwater the area enclosed by

the cofferdams and shall maintain all parts of the work free from water as required for the prosecution of the work. The contractor shall furnish, install, maintain, and operate all pumps and appurtenant equipment, including suitable equipment for measuring the water removed. Pumps for unwatering shall have sufficient capacity to remove the water impounded within the cofferdams in not more than 15 days. The capacity of the pumps provided and the general location and arrangement shall be subject to the approval of the contracting officer, who may order the installation of additional pumps and equipment if, in his opinion, such action is necessary to insure the safety of the structure, the progress of the work or to maintain working areas free from water. After the power house gates have been installed, the contracting officer may require that pumping be stopped and no further payment will be made for subsequent unwatering.

(b) Flooding. - Stop logs are specified in the downstream cofferdam so that the entire area may be flooded whenever extreme high water conditions threaten damage to the cofferdams, the work in progress or surrounding property. The contractor shall maintain the stop logs in perfect operating condition at all times and shall operate them as and when directed by the contracting officer.

Although it is contemplated that every effort will be made to avoid the necessity of flooding the work area, nevertheless the contractor shall make provision each year as the ice gorge season approaches so that the minimum amount of damage shall result should flooding be necessary. To this end he shall provide by revetment or by protection with planks, sheeting, brush or rock, as directed by the contracting officer, a suitable channel leading from the sluiceway to a low point in the work area so that exessive scour will be avoided. Such works shall be located with reference to the existing state of excavation at the time and may be removed after the danger of ice gorges has passed for the year.

Payment for such work will be made as specified in Articles 3 and 4 of the contract.

2-08. MEASUREMENT AND PAYMENT. -

(a) Timber Cribs. - Payment for timber cribs shall include all work of unloading, transporting, and storing material, construction, and maintaining cribs, placing as specified and shown on the drawings, and the furnishing and placing of all materials. Payment will be made at the contract unit price per thousand board feet for "Timber Cribs". After a crib has been set and stabilized with fill. The number of board feet shall include all crib timber in place except sheathing lumber. The bridge over the sluices shall also be included in this pay item. Dimensions of timber serving as a basis for computation of quantities of board feet will be in accordance with standard grading rules of the applicable lumber organization.

(b) Crib Sheathing. - Payment for furnishing and placing crib sheathing will be made at the contract unit price per square foot for "Crib Sheathing". This item shall include only the built up watertight sheathing for cribs, as specified in paragraph 2-06(c).

(c) Steel Sheet Piling. - Payment for furnishing and placing steel sheet piling will be made at the contract unit price per square foot for "Steel Sheet Piling", for the number of square feet of wall below the specified grade line.

(d) Crib Fill. - Crib fill shall be measured in place to the inside dimensions of the orib pookets. Payment will be made at the contract unit prioe per oubio yard for "Crib Fill".

(e) Earth fill, Rook Fill, and Riprap. - These items shall be measured in plaoe to the slope and grade lines as speoified or shown on the plans. Payment will be made at the oontract unit prices per oubio yard for "Earth Fill; Compaoted Class I; Cofferdam, ""Earth Compaoted Class II, Cofferdam" and "Earth Fill; Class III, Fill; /Cofferdam", and "Riprap; respeotively.

(f) Corrugated Iron Pipe. - Corrugated iron pipe will be measured in place as shown on the drawings. Payment will be made at the oontraot unit price per linear foot for "Corrugated Iron Pipe;" 12 inoh Diameter.

(g) Sand and Gravel Backing. - Sand and Gravel backing will be measured to the slope and grade lines as shown on the drawings. Payment will be made at the oontraot unit prioe per ou. yd. for "Sand and Gravel Baoking." (See also paragraph 4-07(o)).

(h) Filter. - Filter will be measured to the slope and grade lines as shown on the drawings. Payment will be made at the oontract unit price per ou. yds. for "Filter." (See paragraph 4-06(o)).

(i) Unwatering Cofferdams. - Payment for unwatering cofferdams inoluding maintaining all parts of the work free from water as required will be made at the oontraot unit prioe per aore foot for "Unwatering Cofferdams."

(j) Cofferdam Removal - Cofferdam removal shall be measured on the basis of material actually in plaoe above the grade speoified for removal and no olassifioation of material will be made. Payment will be made at the contraot unit price per cubio yard for "Cofferdam Removal" and shall inolude all work as speoified including disposal and olean-up.

SECTION III

EXCAVATION, FOUNDATION PREPARATION, AND GROUTING

3-01. CLEARING AND GRUBBING. -

(a) The work areas as shown on drawing sheet No. 2 shall be cleared according to the following:

(1) The borrow areas and the excavation area for the construction of the power house and wing walls shall be cleared of all trees, brush, fences, buildings and any other objectionable material as directed by the contracting officer.

(2) In areas to be covered by spoil, trees shall be cut off at elevations not higher than 4 feet below top of spoil dump.

(3) The foundation areas of embankments for Class I and Class II compacted earth fills, filter blankets and rock protection shall be cleared and grubbed of all trees, stumps, roots, brush, fences, buildings and any other objectionable materials. In foundation areas to be stripped as shown on the contract drawings, all roots 1 1/2 inches in diameter or greater shall be grubbed to a minimum depth of 4 feet below the ground. Trees in the foundation areas for Class III fill and in 50 ft. wide strips outside the toe of all embankment slopes, except as otherwise required, shall be cut off at elevations not higher than 2 ft. above ground surface.

(4) All work areas upstream of the power house and on pool side of dikes below elevation 250 shall be cleared of trees, brush, fences, buildings and any other objectionable material. All trees shall be cut off 2 feet above the ground surface except that no stumps shall remain above elevation 230. Where trees stand on ground between elevation 230 and 250, they shall be cut off flush with the ground.

(b) All trees, stumps, roots, brush, fallen timber, buildings, and other debris cleared within the areas indicated above shall be burned, buried in spoil areas, or otherwise completely removed from the site to the satisfaction of the contracting officer. Disposal in the river of trees, stumps, roots, and other harmful material will not be permitted, and no material shall be piled in the stream bed or on the river terrace where it may be washed away by highwater. The contractor shall be responsible for any damage done by fire, and shall at no time leave a fire unattended until it has been fully extinguished.

(c) No separate payment will be made for clearing and grubbing, but the cost of doing such work shall be included in the contract unit prices for other items of work.

3-02. EXCAVATION REQUIREMENTS. -

(a) Excavation and stripping shall be carried to the lines and grades shown on the drawings or as directed by the contracting officer. Excavation and foundation preparation for the various sections of the power house and dikes shall be performed in accordance with paragraphs 3-06, 3-08, 3-09 and 3-10 of these specifications, or as otherwise directed by the contracting officer.

(b) Borrow Pits. The designated borrow areas to obtain embankment materials are indicated on the drawings (see paragraph 1-16). It is estimated that in the designated borrow areas and in the required excavation there is sufficient quantity of suitable material for the compacted fill sections of the embankments, but if, in the opinion of the contracting officer, additional borrow pits are required, they will be furnished without cost to the contractor.

3-03. CHARACTER OF MATERIALS TO BE EXCAVATED. - The location samples and logs of borings, test trenches, and test pits referred to in paragraph 1-18(a) made by the United States to determine the character of materials to be encountered and removed or to be used in the earth embankment are shown on the drawings or are available for inspection at the U. S. Engineer Office, Massena, New York. The United States does not guarantee that other materials will not be encountered nor that the proportions of the several materials will not vary from those indicated by the explorations. (See paragraph 1-18 (a).)

3-04. EXCAVATION IN BORROW PITS AND STOCK PILES.

(a) Borrow Pits. - The contracting officer will specify the location at which borrow excavation will be made within the borrow areas. The specified areas shall be cleared and grubbed as slated in paragraph 3-01, and stripped to a depth of 18 inches, or as otherwise directed by the contracting officer. The suitable top soil from stripping shall be stock piled for future use by others. All other materials from stripping shall be finally disposed of in the excavated portions of the borrow areas. The depths of cuts and lifts and the disposition of the excavated materials may require the contractor to change the locations and depths of his excavating operations whenever such change is, in the opinion of the contracting officer, necessary to obtain the proper quality of material. The excavations shall be worked so that the materials are mixed in the process of excavation. Excavation within the borrow pits shall be in a manner to produce drainage of the material if the ground water table is above the elevation of the excavation. After the excavation is completed, excavated surfaces above elevation 230 shall be graded to a smooth and pleasing appearance, and as directed by the contracting officer. (See also paragraph 1-16).

(b) Stock Piles. - Earth fill materials from stock piles shall be obtained in a manner satisfactory to the contracting officer. The contractor will be required to excavate in the areas as directed and change the locations and depths of excavating operations wherever such a change is directed by the contracting officer. The final surfaces of the remaining part or parts of the stock piles of earth fill shall be graded and blended into the surrounding topography in a manner satisfactory to the contracting officer.

Rock materials from stock piles shall be obtained in a manner satisfactory to the contracting officer. After the excavation of the stock pile of rock is completed, the remainder of the material shall be gathered and neatly piled as directed by the contracting officer.

3-05. CLASSIFICATION OF EXCAVATION. -

(a) Rock Excavation - All bedrock required to be excavated which, in the opinion of the contracting officer, cannot be removed without continuous and systematic blasting, and all boulders and loose rock two cubic yards in volume or greater will be classed as rock excavation.

(b) Common Excavation. - All other material will be classified as

common excavation, including boulders and loose rock less than two cubic yards in volume. (See paragraph 3-07(b) (2))

3-06. REMOVAL AND DISPOSAL OF EXCAVATION. -

(a) Removal. - All materials shall be removed to the lines and grades as indicated on the drawings, or as otherwise required by the contracting officer, to provide suitable foundations as specified below. Overburden adjacent to vertical rock cut surfaces shall be trimmed back on a 1 to 1 sloped from the rock surface, unless otherwise shown on the drawings. The contractor shall provide and maintain all sheeting, bracing, and other protection that is necessary to protect these slopes or excavate beyond these lines if such procedure is required by the condition of the material; but such additional excavation beyond the slopes shown shall not be included in the quantities for payment.

(1) Excavation for Concrete Structures, and Forebay and Tailrace Channel. Excavation for the concrete power house structure and wing walls, shall be carried to a satisfactory firm foundation as determined by the contracting officer after completion of sub-surface explorations. The foundation grades shown on the drawings are only approximate and are not guaranteed. Should actual frim rock be encountered at a higher or lower elevation than the approximate foundation grades shown on the drawings, no change will be made therefore in the contract unit prices. Excavation for forebay and tailrace channels shall be carried to the lines and grades shown on the drawings.

(2) Stripping for Dike Embankments. Embankment areas shall be stripped and excavated to lines and grades, and slopes as shown on the contract drawings or as directed by the contracting officer. The contractor shall de-water all excavation areas to produce a dry condition suitable for placing embankment as determined by the contracting officer. Explorations indicate that it will be necessary to remove silt and clay deposits in certain areas for dike foundation. Should excavation be required to a higher or lower elevation than that indicated in the drawings, as determined by the contracting officer, no change will be made therefore in the contract unit prices.

(b) Disposal. - The excavated materials shall be disposed of as follows unless otherwise directed by the contracting officer. All material excavated which is suitable, as determined by the contracting officer, for the earth dikes and for backfill around the power house structure, shall be placed directly in the earth section of the dikes, backfill or in stock pile areas approved by the contracting officer. Suitable material may be used for raising cofferdam C, (See paragraph 2-05(d)). All other material not suitable or in excess of that required for backfill and the embankments of the dikes shall be disposed of in the spoil areas shown on the contract drawings in a manner and to an elevation satisfactory to the contracting officer.

Rock obtained during the excavation for concrete structures which passes the specifications for stone protection (See paragraph 4-08) shall be placed directly in the rock fill section of the dikes or in areas where protection stone is required (See drawings) or in stock piles. All rock except shale in excess of that required for the rip-rap for the work included under this contract shall be stockpiled in areas and in a manner approved by the contracting officer. Shale shall be disposed of in designated spoil areas.

3-07. MEASUREMENT AND PAYMENT FOR EXCAVATION.

(a) Measurement.

(1) A survey of the ground surface for foundation excavation will be made prior to commencement of work and measurements of excavation will be based on this survey and on the classifications specified in paragraph 3-05. Measurement for common excavation will be made between the ground surface and the slope and grade lines shown on the drawings (See paragraph 3-06(a)) or as modified by the contracting officer, or to the natural rock surfaces encountered in such excavation.

(2) A survey of all borrow areas and earth stock piles will be made prior to the removal of material. Measurement of excavation for embankment materials for payment will be based on this survey, and a final survey of the completed excavation.

(3) Measurement for rock excavation will be made for the actual quantity excavated within the slope, structure, and grade lines shown on the drawings, or such modifications of these lines as directed by the contracting officer. No payment will be made for any rock excavation carried below or beyond these lines by unnecessary drilling and blasting and all rock thus removed, shall be replaced with concrete at the expense of the contractor.

(4) The excavation payment slope lines shown on the drawings do not represent actual slopes necessary and are not guaranteed by the Government as safe slopes for making the required excavations. The contractor shall take such precautions as may be necessary to protect the work. (See paragraph 3-06(a))

(b) Payment.

(1) Payment for all required excavation shall include the cost of excavation, transporting and disposal as required under par. 3-02 and 3-06 and will be made at the respective contract unit prices per cubic yard for "Excavation; Common"; and "Excavation; Rock". (See also paragraph 15-04)

(2) Payment for common excavation which, in the opinion of the contracting officer, cannot be removed by a 2 1/2 cubic yard power shovel without continuous and systematic blasting will be made at twice the contract unit price per cubic yard for "Excavation; Common".

(3) Where stockpiling of excavated material except rock prior to its incorporation in fill is directed by the contracting officer, separate payment will also be made for excavating from these stock piles at the rate of 50 per centum of the contract unit price for "Excavation; Common"; provided, however, that no payment will be made for stockpiling when and where the contractor is offered the alternative of suspending excavation but elects to stockpile in lieu of suspension. The alternative of suspending excavation will be offered only when and to the extent that in the opinion of the contracting officer progress has been such as to warrant it. Such offer shall not constitute a basis for extension of time limit under the contract. No separate payment will be made for excavation from rock stock piles.

3-08. FOUNDATION PREPARATION -

(a) Rock. - Foundation excavation for the power house and wing walls shall be carried to the lines and grades as indicated on the drawings, and/or to sound, firm ledge rock, free from open horizontal seams or disintegrated portions. Blasting against surfaces which will form the final surface will not be permitted, (See paragraph 3-10). The foundation shall be prepared by barring, picking, wedging, or similar methods which will leave the rock of the foundation in an entirely sound and unshattered condition. The surface of the rock shall be left clean and rough to provide a proper bond between the rock and the concrete. All water shall be removed from the final foundation,

which shall be moistened as required by the contracting officer prior to initial placement of grout. The contractor will be required to drill exploratory core holes as described in paragraph 3-11 in the foundation to determine the suitability of the bedrock. Payment for rock foundation preparation will be included in payment for rock excavation.

3-09. LINE DRILLING.

(a) The vertical faces indicated on the drawings or as otherwise required by the contracting officer shall be made with a channeling machine, by drilling and broaching or by close line drilling. Rock excavation adjacent to channeled faces shall be removed in shallow lifts and short sections, and the channeled face remaining shall be of undisturbed rock.

(b) Measurement for line drilling will be made along the vertical surface indicated on the drawings or established by the contracting officer. Payment for channeling, drilling and broaching or close line drilling will be made at the contract unit price per square foot of vertical surface for "Line Drilling". Payment for the rock removed will be made as specified in par. 3-07.

3-10. BLASTING FOR EXCAVATION. - Blasting will be permitted only when proper precautions are taken for the protection of all persons, the work and property, and any damage done to the work or property by blasting shall be repaired by the contractor at his own expense. Caps or other exploders or fuses shall in no case be stored or kept in the same place in which dynamite or other explosives are stored. All operations of the contractor in connection with the transportation, storage and use of explosives shall be subject to the approval of the contracting officer, and the contractor shall be liable for all injuries or deaths of persons or damage to property caused by blasting or explosives. All necessary precautions shall be taken to preserve the rock outside the lines of excavation in sound condition. Blasting may be done only to the depth, amount and extent approved by the contracting officer. Approval of the method of blasting by the contracting officer, as specified in this sub-paragraph, will not relieve the contractor of his responsibility in blasting operations, and no payment will be made for any rock required to be excavated outside of the limit lines indicated on the drawings or below the grade lines established in the field, or modifications thereof directed by the contracting officer, solely due to injury caused by the overshooting, improper blasting or carelessness on the part of the contractor, and all rock thus removed shall be replaced by concrete at the expense of the contractor, including the payment for all cement used in such concrete and furnished by the United States. No blasting shall be done within one hundred (100) feet of concrete which has been in place less than seven (7) days.

3-11. DRILLING EXPLORATORY AND GROUT HOLES.

(a) General. - For the purpose of canvassing bids, the approximate extent of a tentative program for drilling exploratory and grout holes is outlined herein. The Government reserves the right, however, to alter the location and depth of the exploratory and grout holes, and no change will be allowed in the contract unit prices because of such alteration. The contractor shall, at the applicable contract unit prices, drill exploratory and grout holes at such locations and at such inclinations not to exceed twenty (20) degrees from the vertical, and to such depths, subject to the limitations hereinafter specified, as may be required by the contracting officer.

(b) Method of Rock Core Drilling. - Core drilling through rock shall be done with standard core drilling equipment using diamond or alloy bits designed to furnish complete standard cores a minimum of 2 inches in diameter from holes 3 inches in diameter. The contractor shall run his drills at such speeds as will insure satisfactory core recoveries, and the contracting officer may require, without compensation, the redrilling of those holes from which the cores are unsatisfactory if the contractor's operations are at fault. Except where drilling of a hole is ordered stopped by the contracting officer, holes that cannot be drilled to the depth directed, due to any cause, shall be redrilled without additional expense to the government.

(c) Exploratory Core Holes. - The rock foundation area covered by the power house structure and areas adjacent thereto shall, after removing overburden, be further explored by rock core drilling. The layout of holes shall be as directed by the contracting officer. These holes in the foundation rock are intended to determine the location of suitable rock for the foundation of the power house structure. It is expected that at least one drill hole will be required in the foundation of each concrete monolith founded on rock, as shown on the drawings. However, the contracting officer may direct that additional holes be drilled under each monolith or at other locations. The depth of these holes shall be as directed by the contracting officer. Concreting shall not be commenced in any section until after the contractor has received written approval of the foundation for placing concrete for each monolith.

(d) Grout Holes. - Holes for grouting shall be drilled as described in paragraph (b) above, at intervals and to the depths hereinafter specified (See Paragraph 3-12(b)) under the power house structure as shown on the drawings. These holes shall be drilled from the grout gallery after the concrete has been placed. Grout holes through the concrete may be obtained by percussion drilling or by placing 4 inch diameter steel pipes prior to concreting, as directed by the contracting officer. If pipes are used, they shall be carried up to 6 inches above grout gallery floor, and shall be threaded and capped. The holes shall be vertical, or inclined not to exceed 20 degrees from the vertical, as directed by the contracting officer. After completion of grouting, the pipe extending above the grout tunnel shall be burnt off flush. The contractor will be required to protect the concrete surfaces during all drilling and grouting operations and no separate payment will be made for such protection. When the drilling of each hole has been completed, the hole shall be protected from being clogged or obstructed until it is grouted. Any hole that becomes clogged or obstructed prior to grouting shall be opened up to the satisfaction of the contracting officer, and no separate payment will be made therefor.

(e) Core Boxes. - The contracting officer may require that the 2-inch cores from certain holes be preserved and stored in core boxes. Core boxes for storing the cores shall be furnished at the site by the contractor. All cores shall be in the custody of the contractor until transported from the site by a representative of the contracting officer, and while in his custody shall be protected from the weather. All boxes shall be of pine or similar soft lumber of lightweight, non-warping and substantially constructed with suitable partitions with the top of the box hinged and with suitable hasp fasteners. Partitions in the boxes shall run lengthwise, be securely fastened and shall be approximately 1/8 inch farther apart than the diameter of the

rock core to be placed in the box. Spacers to separate the rock core obtained by each run shall be soft wooden blocks to fit between the core box partitions and 1-1/2 inches in length. The core boxes shall be of uniform size 4 feet in length and approximately 12 inches wide, and shall meet with the approval of the contracting officer. All cores shall be neatly arranged in the sequence in which they are removed from the hole, and be properly identified.

(f) Filling Exploratory Holes with Grout. All exploratory core holes shall be filled with grout consisting of sand and cement of such mixtures as determined by the contracting officer. Sand for grouting shall be as specified in par. 3-12(e). The holes shall be filled with grout by means of equipment for pressure grouting as described in par. 3-12(d). In filling the exploratory core holes no leakage tests are required and the hole being filled shall not be sealed.

(g) Measurement and Payment. All measurements for payment shall be made by or in the presence of an authorized representative of the contract officer.

(1) Measurement for payment of grout holes in concrete will be from the concrete surface to the foundation rock surface. Measurement for payment for holes in rock will be from the foundation rock surface to bottom of hole. Payment for drilling grout holes in concrete will be made at the contract unit price per linear foot for "Drilling Grout Holes in Concrete". Payment for furnishing and placing 4-inch steel pipe for grout holes will be made at the contract unit price per pound for "Grout Pipes and Connections" (See also paragraph 5-18(g) Payment for drilling grout holes in rock will be made at the applicable contract unit price per linear foot for "Drilling Grout Holes in Rock", which payment shall include drilling, core recovery, pressure testing, protection of the completed hole and all costs in connection therewith.

(2) Measurement for payment of exploratory holes will be from the foundation rock surface to bottom of hole. Payment for drilling exploratory cored holes in rock will be made at the applicable contract unit price per linear foot for "Drilling Exploratory Holes" which payment shall include drilling, core recovery, mixing and placing the grout filling and all costs in connection therewith.

(3) Core boxes that are required to store cores from grout holes and exploratory holes will be paid for at the contract unit price each for "Core Boxes", which payment shall include all costs for transporting and storage in connection therewith.

3-12. PRESSURE GROUTING FOUNDATION. -

(a) Pressure Testing. - Before any hole is grouted it shall be pressure tested with water for leakage at intervals as directed by the contracting officer throughout the full depth of the hole. The contractor shall furnish the necessary equipment and make the tests. The equipment shall provide capacity sufficient to test the grout holes at pressures up to 150 pounds per square inch. A suitable gage shall be installed in the pressure line at the hole being tested so that pressures in the hole will be indicated at all times. A water meter reading directly to a 0.1 cubic foot per minute shall be installed in the pressure line to measure the leakage from the hole. The pressure shall be varied with the depth at the direction of the contracting

officer. From the test results, the contractor shall furnish information indicating the location and amount of each leakage. Payment for pressure testing will be included in the contract unit price for "Drilling Foundation Grout Holes in Rock".

(b) Procedure.

(1) The first grout holes shall be drilled on 100 foot centers for the grouting curtain cut off and shall extend to a depth of about 25 feet below the gypsum layer. These holes will be approximately 140 to 170 feet deep and shall be pressure tested at 20 foot intervals or closer as directed by the contracting officer, to determine the depth to which the grout holes on 10-foot centers, lying between the primary 100-foot spaced holes, will be drilled.

(2) Intermediate grout holes shall be drilled at intervals of 10-feet across the entire concrete structure between the outside ends of the wing dams. The holes shall be drilled and cores recovered, as specified above, to a depth as directed by the contracting officer. These holes shall be pressure tested as specified in paragraph 3-12 (a) above.

(3) All the holes shall be thoroughly washed out and grouted according to the procedure specified in paragraph 3-12(e). Should seams connect between any adjacent grout holes these holes shall be interconnected and simultaneously washed and then simultaneously grouted. If more than three holes join any one seam, seals and connections will be required, of a design approved by the contracting officer, to simultaneously grout the holes.

(4) After the grout holes on 10-foot centers have been satisfactorily grouted and not sooner than 48 hours thereafter in the same locality test holes shall be drilled midway between and to the same depth as the adjacent holes. These test holes shall be drilled, tested, and if found to leak more than approved by the contracting officer, they shall be grouted by the same method as the adjacent holes.

(5) This method of drilling and grouting shall continue until the grouting has been accepted as complete, i.e., when a hole is drilled and found necessary to grout, holes shall be drilled each side of the grouted hole at one-half the previous interval, and the same testing, washing, and grouting procedure shall be followed until leakage is stopped or reduced to a limit acceptable to the contracting officer.

(c) Grouting Equipment

(1) The equipment to be used for mixing and injecting the grout shall be subject to the approval of the contracting officer. The grouting unit shall provide:

a. A grout mixer for mixing the ingredients.

b. A suitable water meter with straight-reading register, reading to the nearest 0.1 cubic foot for measuring the mixing water.

c. A water tank for auxiliary water supply to be used for pressure testing and for flushing pumps, lines, and holes.

d. A mechanically agitated sump to prevent the segregation of ingredients after mixing and to maintain a supply during the mixing period,

e. Two duplex displacement grout pumps so piped and assembled as to provide interchangeable, continuous, and effective injection of grout at any desired pressure, not to exceed 250 pounds per square inch.

f. Air compressors of suitable capacity, water pumps, and auxiliary equipment.

(2) The mixer and sumps shall each have a volume of not less than 15 cubic feet. The assembled unit shall allow the injection of 150 cubic

feet of solids per hour at 150 pounds per square inch pressure, if desired. The grouting equipment shall be maintained in a manner satisfactory to the contracting officer and so as to insure continuous and effective performance during any grouting operation. Circulating grout lines shall be not less than 1-1/2 inches in diameter and are to be controlled by suitable valves in the header and piping so that all or part of the grout can be injected into the hole, or all or part returned to the sump. A suitable pressure gage shall be provided at the hole as well as at the pump for indicating the pressure during the injection of grout. The pressure gage shall be installed in the header near the hole being grouted. By-passing of the grout back to the sump tank shall be near the hole being grouted and not at the machine. Grout stops or packers are to be provided which shall consist of an expanding seal of rubber having a length of 6 inches and a diameter of 3 inches or as directed by the contracting officer. Miscellaneous calking tools and hammers and labor for calking shall be furnished by the contractor as directed by the contracting officer.

(d) Composition of Grout and Method of Placement. - Grout shall consist of a mixture of Portland cement and water with or without an admixture of sand or rock flour in proportions as directed by the contracting officer, but not to exceed 3 parts of sand or rock flour to 1 part of cement. The type of mixture of grout to be used will be determined by the nature of the seams to be grouted and as directed by the contracting officer. Sand, if used, shall be of such fineness that 100 percent will pass a No. 28 standard sieve and 25 percent will pass a No. 100 standard sieve. Rock flour, if used, shall be dust obtained by crushing dolomite rock and it shall be at least as fine as specified above for sand. Cement for grouting will be furnished by the Government in paper bags (See paragraph 1-10(d)). Prior to pressure grouting, all grout holes shall be sounded and, if necessary, shall be thoroughly washed and cleaned with water under continuous pressure or by compressed air and water in a manner which will permit free overflow of waste water, by inserting a smaller pipe and introducing the wash water at the bottom of the hole. The speed of operation of the grout pump and the grouting pressure shall be as directed by the contracting officer. In general, it is expected that pressures up to 150 pounds per square inch will be required for the deeper sections of the holes, while lower pressures will be used for the upper zones. Grouting shall be continued until the hole takes the grout mixture at a rate of less than one cubic foot in 10 minutes under the required grouting pressure, and the grouting of any hole shall be discontinued when directed by the contracting officer. The contracting officer may require that the grouting of any hole may be temporarily suspended if work is proceeding in an unsatisfactory manner, and the hole protected by suitable means until grouting is resumed. When the grouting of any hole has been commenced, it shall be continued until completion, unless otherwise directed by the contracting officer. In the event of an unavoidable delay during grout injection, the contractor shall supply water at not less than the specified grouting pressure for application to the hole as directed by the contracting officer. After grouting operations for any hole have been completed and the grout set, or if the rock about any hole is in such sound condition that pressure grouting is not necessary, the hole shall be completely filled with grout. When a hole during the grouting procedure shows back pressure it shall be capped or otherwise sealed.

(e) Payment. - Payment for grouting will be made at the contract unit price per cubic foot for "Pressure Grouting." The volume of grout will be

considered to be equal to the volume of cement plus the volume of sand or rock flour used measured in the loose dry state. This payment shall include washing and jetting of grout holes, and all materials, equipment, and labor necessary, except that cement will be furnished by the United States and furnishing of sand or rock flour will be paid for separately. No payment will be made for grout lost due to improper anchorage of grout pipes or connections, nor for grout rejected by the contracting officer because of the improper mixing. Payment for furnishing sand or rock flour used in grouting will be made at the contract unit price per cubic foot for "Sand in Grout" or "Rock Flour in Grout".

3-13. FOUNDATION DRAINS. -

(a) Drain Pipes. - Prior to the placing of concrete, 8 inch black steel pipes shall be set in the foundation at approximately 40-foot centers in vertical or inclined positions not to exceed 20 degrees inclination from the vertical, as shown on the drawings or as directed by the contracting officer. Pipes shall be adequately supported during the concreting operations to preserve the required alignment. Flanges and covers shall be furnished and installed in accordance with details to be shown on future drawings.

(b) Drain Holes. - Drain holes 6 inches in diameter shall be core drilled through the drain pipes after foundation grouting has been completed, to depths of about 25 ft. below the gypsum layer or as directed by the contracting officer, but not to exceed 175 feet below the bottoms of the pipes.

(c) Measurement and Payment. - Payment for furnishing and installing drain pipes included flanges and covers will be made at the contract unit price, per pound, for "Pipe; Black Steel, 8 inch". Payment for drilling drain holes will be made at the contract unit price per linear foot, for "Drilling 6-inch Drain Holes". Payment will be made only for the linear feet drilled below the bottoms of the drain pipes.

3-14. DRILLING 6-INCH CONCRETE CORES.

(a) General. - The contractor shall drill holes in the concrete at such locations and to such depths as may be directed by the contracting officer in order to obtain concrete cores 6 inches in diameter in lengths satisfactory for testing. A tolerance of 1/4-inch will be permitted in the diameter of the cores. The contractor shall mark each core with black paint giving location and elevation. Upon completion of drilling, the contractor shall refill the hole with well rodded concrete of the same mix and water content as that from which the core was taken.

(b) Measurement and Payment.- Payment for drilling 6- inch concrete cores and for refilling holes with concrete will be made at the contract unit price per linear foot for "Drilling 6-inch concrete Cores", for actual core lengths drilled and recovered. The quantity shown in the bidding schedule for "Drilling 6-inch Concrete Cores" is given only for the purpose of canvassing bids and the Government does not guarantee that any of this work will be required or that the quantity will be limited to the amount estimated.

SECTION IV

EMBANKMENTS, BACKFILL AND PROTECTION STONE

4-01. DEFINITION. - The term "Embankments" as used in this section includes the compacted earth fill of dikes; the compacted earth backfill around the power house sections and wing wall sections; the sand and gravel backing, stone protection, and filter blankets of dikes, and all other specified or directed fill and slope protection, except for cofferdams (see Section II) and railroad and highway fills (See Section XV)

4-02. GENERAL PROVISIONS. -

(a) Lines and Grades. - The embankments shall be constructed to the lines and grades shown on the drawings or otherwise required by the contracting officer. The contracting officer reserves the right to change the foundation widths, change the slopes and dimensions of the embankments, change the dimensions and slopes of the foundation cut-off trenches and change the shape and thickness of the dumped stone protection and make such other changes as future studies and conditions on the work indicate as necessary for the construction of a safe and permanent structure as determined by the contracting officer. Changes in quantities of materials resulting from changes in sections shall be no cause for claims of increased contract unit prices.

(b) Materials. - Materials for the various sections of the embankments shall conform to the respective requirements specified in the following paragraphs of this section. No brush, roots, sod, and perishable or objectionable materials, as determined by the contracting officer, shall be placed in the compacted embankments. Any objectionable material placed in the compacted embankments shall be removed by the contractor as directed by the contracting officer, withour cost to the Government. The suitability of each part of the foundation for placing embankment materials thereon and of all materials for use in an embankment will be determined by the contracting officer. No materials shall be placed in an embankment where either the materials or the foundation on which they are to be placed is frozen.

(c) Conduct of the Work. - The contractor shall at all times maintain the embankments in conformity with paragraph 4-04 and 4-05 and in a manner satisfactory to the contracting officer until the final completion and acceptance of all work under the contract. The contractor may be required to suspend work at any time when, in the opinion of the contracting officer, satisfactory work cannot be done on account of rain, floods, cold weather, or other unsatisfactory conditions. Any approved embankment material which is lost or rendered unsuitable after being placed in an embankment and before the completion and final acceptance of the work, due to causes that, in the opinion of the contracting officer, are avoidable, or under the control of the contractor, shall be replaced by the contractor in a manner satisfactory to the contracting officer and without cost to the Government. The contracting officer may require the contractor to remove without cost to the Government any material placed by the contractor outside of specified slope lines.

(d) Order of Work. - The contractor will be required to organize the work so that suitable rock and earth fill materials obtained from the excavation for the construction of the power house structure may be placed directly in the embankment sections, or on cofferdam "C" (See paragraph 2-05(d)).

(e) Approved Materials.- Materials obtained from required excavation for the construction of the power house which are approved for placement in embankments or cofferdam "C" may be wasted or placed in stock piles at the option of the contractor. In case the contractor elects to waste or stock pile these materials he shall obtain equal amounts of approved material form borrow pits in case of waste, or re-excavate from stock piles at his own expense. If there is not sufficient approved materials from the required excavation to construct the forebay dikes, cofferdam "C" and back fill around the power house, the contractor shall secure the additional material from approved borrow areas. All such materials directed to be excavated from approved borrow areas will be paid for at the contract unit price per cu. yds. for "Excavation Borrow".

4-03. - PREPARATION OF FOUNDATION FOR EMBANKMENT. -

(a) General - The foundations for the embankments shall be stripped and excavated as specified in Section III. The test pits, stump holes and other excavated areas, depressions and cavities within the limits of the embankment shall be filled with compacted earth as directed by the contracting officer. This earth fill shall be placed in layers, moistened and compacted in accordance with the requirements for Class I fill, see paragraph 4-04. As the fill is brought up, the side slope of the cut or hole shall be scarified, if, in the opinion of the contracting officer, it is required in order to provide a bond between the fill and the original ground material. The sides of all holes shall be broken down if necessary so as to flatten out the slopes, and the hole then filled with approved material and properly rolled or tamped in place. Immediately prior to placing Class I and II materials in embankments, the entire foundation, except areas to be covered by sand and gravel filter, shall be scarified to a depth of 4 inches. A 4-inch layer of embankment material shall be spread and compacted as specified for Class I fill in paragraph 4-04(e). The foundation upon which fill is placed shall be in a suitable dry condition, as determined by the contracting officer.

(b) Measurement and Payment. - Payment for the fills in the foundation areas indicated above will be made in accordance with paragraph 4-04(h). No payment as a separate item will be made for other work necessary for the preparation of the foundation including unwatering the foundation areas of the embankments, but the cost of these items shall be included in the contract unit prices for the other items of work connected with the embankments.

4-04. CLASS I AND CLASS II COMPACTED EARTHFILLS. -

(a) General. - The earth sections of the embankments shall be constructed of Class I and Class II compacted earth fill as shown on the drawings. Manner of compaction shall be as specified in paragraph (e) below.

(b) Material. - Materials for the Class I and Class II compacted earth fills shall be secured from the required excavation for the power house (see paragraph 3-03) and for the embankment foundations, or from borrow areas (see paragraph 3-04(a)). The materials in general will be a well graded clayey or silty sand and gravel. No stones which would be retained on 6-inch screen will be permitted in the Class I compacted earth fill. No stones which would be retained on an 8-inch screen will be permitted in the Class II compacted earth fill. Should stones of such size be found in the otherwise approved earth fill embankment materials, they shall be removed by the contractor. Suitable stones removed may be used for riprap or rock fill as specified in paragraph 4-03. Each load of material to be placed in

either Class I or Class II compacted earth fill shall be the equivalent, as nearly as practicable, of a mixture of materials obtained from an approximately uniform strip or cutting from the full height of a lift in excavation. The combined excavation and embankment placing operations shall be such that the materials when compacted in the fill will be blended sufficiently to secure the greatest homogeneity and desired density.

(c) Placement.- The distribution and gradation of materials throughout the Class I and Class II compacted earth fill sections of the embankments shall be such that the embankments will be free from lenses, pockets, streaks or layers of materials differing materially in texture or gradation from the surrounding materials. The dumping of successive loads of earth fill materials from the different parts of the borrow areas, stock piles or required excavations shall be at locations in the embankment as directed by the contracting officer, and for this purpose, the contracting officer may direct the points in the embankments where individual loads of material shall be deposited to the end that the more pervious material shall be placed in the downstream sections of the dikes and the outer sections of the backfill. After dumping, the materials shall be spread by bulldozers or other approved methods in approximately 8-inch layers over the prepared foundation or fills. Materials in small or confined areas where compacting by rolling is impracticable, as determined by the contracting officer, shall be spread in layers 4 inches in thickness before compacting. All layers shall extend at an approximately uniform elevation over the entire width of the embankment and for the entire length of the section under construction unless otherwise directed by the contracting officer. The top surfaces of the Class I and Class II compacted earth fills during construction shall be kept crowned with grades not less than 2 nor more than 4 percent, so that the surface of the fill will drain freely toward the slopes. The surface of the fill shall be maintained at all times in such a manner that no water pockets will be formed under any weather conditions. If work is stopped on any part of the Class I compacted earth fill for a period of time, the area to remain standing shall be rolled with a smooth-faced roller to prevent loss of moisture and to facilitate drainage. If, in the opinion of the contracting officer, the rolled surface of any layer of any section is too smooth to bond properly with the succeeding layer or adjacent section, it shall be roughened or loosened by scarifying to the satisfaction of the contracting officer before the succeeding layer is placed thereon. Ruts in the surface of any layer shall be filled in a manner satisfactory to the contracting officer.

(d) Moisture Control.-

(1) The materials in each layer of the Class I and Class II compacted earth fills while being compacted shall contain moisture within a few percent of the optimum, as determined by the contracting officer, for the compaction desired. Prior to and during construction, the contracting officer will establish the limiting ranges of moisture contents for materials to be compacted in Class I fill and Class II fill. The moisture content shall be uniform throughout the layer. If the application of water is necessary, it may be done either at the excavation area or at the embankment. Wetting at the excavation area shall be supplemented as required by sprinkling in place on the embankment, if in the opinion of the contracting officer it is necessary. The contractor shall maintain adequate facilities to provide the amount of water required.

(2) No layer of material shall be placed if the moisture content of the exposed surface on which it is to be placed is not within the range established by the contracting officer. The contractor shall correct the moisture content of the compacted layer if the moisture content is not

within the required limits.

(e) Compaction. - Class I and Class II fill shall be rolled and compacted with the equipment listed in paragraph (f) below. Each layer of Class I fill shall be compacted by no less than 6 passes of trips and each layer of Class II fill shall be compacted by not less than 2 passes or trips, of a sheepsfoot roller. Each pass of a roller shall overlap the adjacent rolled area by at least 2 feet. In areas where rolling operations are impracticable as determined by the contracting officer, compaction shall be obtained with power tampers of a type approved by the contracting officer to give compaction equal to that required for the adjoining compacted earth fill. If the moisture content is greater or less than that required for compaction, the rolling or tamping shall be delayed until the proper moisture content as determined by the contracting officer has been reached.

(f) Equipment for Compaction by Rolling. - Equipment consisting of an oscillating double section sheepsfoot tamper roller, pulled by a crawler type tractor weighing not less than 20,000 pounds and which is weighted, or equipped with a bulldozer, or both, to increase its total weight to not less than 29,000 pounds, shall be used for compacting the fill. The use of more than 2 rollers in tandem will not be permitted. One passage of two rollers in tandem will be considered as two passes of a sheepsfoot roller. The design and operation of the compacting equipment shall be subject to the approval of the contracting officer. The speed of the compacting equipment shall be not more than 2½ miles per hour. Each drum of the oscillating double section sheepsfoot tamper roller shall be approximately 4 feet in width and shall have tamping feet uniformly staggered over its cylindrical surface and be provided with cleaners. Each tamping foot shall project approximately 7 inches from the roller's cylindrical surface and at no time during operation shall have a face area less than 5 nor more than 7 square inches. The spacing shall be such as to provide not less than 1½ tamping feet for each square foot of cylindrical surface. The sheepsfoot roller shall be weighted so that the total weight of the roller and ballast in pounds divided by the total areas of the maximum number of tamping feet in one row generally parallel to the axis of the roller shall provide for a range of 250 to 400 pounds per square inch by varying the roller ballast.

(g) Tests for Compaction.- Samples for testing of all materials in the embankments, both before and after placement and compaction, will be taken by the contracting officer at frequent intervals. Corrections, adjustments, and modifications of methods may be required as the result of these tests for materials, moisture content, or additional compaction of the materials, in the embankment. In taking samples for control and record purposes, the contractor shall supply labor required to assist the inspector as directed by the contracting officer. During the construction of the embankments, it maybe necessary for the contractor as directed by the contracting officer to construct test embankments which will form part of the completed fill to determine the number of passes or moisture content necessary to obtain the desired compaction.

(h) Additional Compaction.- If the tests specified above indicate that the desired compaction of the materials in the Class I and Class II compacted earth fills is not secured by the compaction specified in paragraph 4-04(e), additional compaction may be required by the contracting officer. Additional compaction shall consist of making not less than 2 passes of a sheepsfoot roller specified in paragraph 4-04(f) over such designated areas. Each pass of a roller shall overlap the adjacent rolled area by at least 2 feet. This procedure will be repeated as often as is necessary to

obtain the desired compaction.

(i) Measurement and Payment.

(1) Measurement of Class I and Class II compacted earth fills placed in the embankments will be made between the lines indicated on the drawings and the required stripping or excavation lines. Payment for Class I and Class II compacted earth fill will be made at the contract unit price per cubic yard for "Earth Fill Compacted Class I" and "Earth Fill Compacted Class II", (See also paragraph 15-04), which payment shall include all incidental work specified or required such as transporting and spreading, mixing, scarifying, harrowing, moistening, drying, compacting, removing oversize stones and objectionable materials, furnishing laborers for sampling, and constructing test embankments.

(2) Payment for each additional two passes of a roller as required by the contracting officer will be made at the contract unit price per square (100 sq. ft.) for "Additional Compaction."

4-05. CLASS III FILL

(a) General. - Material for Class III fill shall be any earth or rock material secured from the required excavations for the forebay, tailrace and foundations. The material need not meet the requirements for Class I material. Class III fill may be placed by dumping to any depth convenient and no special compaction is required. If any soft or compressible material is included in the fill, it shall be distributed to the satisfaction of the contracting officer to avoid excessive unequal settlement.

(b) Measurement and Payment. - Measurement for Class III fill will be made between the final surface indicated on the drawings or as modified by the contracting officer, and the original surface. Payment for Class III fill will be made at the contract unit price per cubic yard for "Earth Fill; Class III" which payment shall include all incidental work specified or required such as transporting, spreading and maintaining the surface for satisfactory operations.

4-06. FILTER . -

(a) General. - Filters shall be constructed in 12-inch layers at the locations and to the lines and grades shown on the drawings, or at such other locations as may be required by the contracting officer. Each 12-inch layer shall be compacted in the same manner as for Class II fill, (See Paragraph 4-04(e)). The material shall conform to the requirements specified in the following paragraph and, if practicable during construction, shall be kept to the same height as the adjacent fill material. Any material encountered in the required excavation that meets the requirements of paragraph (b) below may be used for the filter. Additional materials required for the filter not obtainable form required excavation shall be obtained from other sources by the contractor.

(b) Filter Material.- The material for filters shall be well graded sand, or sand and gravel, which after placement, shall contain at least 40 percent by weight which will pass a $\frac{1}{4}$-inch mesh screen and no stones shall be larger than 6 inches. Of the material passing the $\frac{1}{4}$-inch screen at least 80 percent by weight shall pass a No. 10 mesh screen, and not more than 10 percent shall pass a No. 200 mesh screen. Samples of the material the contractor proposes to use shall be submitted to the contracting officer at least 30 days prior to the date that the contractor plans to commence

placement of filter.

(c) Measurement and Payment . - Measurement of filter material will be made between the lines indicated on the drawings, or as modified by the contracting officer. Payment for furnishing and placing filter material, regardless of source (see paragraph 1-16) will be made at the contract unit price per cubic yard for "Filter." (See also paragraph 2-08(H)).

4-07. SAND AND GRAVEL BACKING. -

(a) General. - Sand and gravel backing for riprap on slopes shall be constructed to the lines and grades shown on the drawings. During construction the placing shall be kept at substantially the same level as the compacted earth fill. Any material encountered in the required excavation that meets the requirements of paragraph (b) below may be used for sand and gravel backing. Additional materials required for the sand and gravel backing not obtainable from required excavation shall be obtained from other sources by the contractor.

(b) Material. - Material for sand and gravel backing shall consist of bank run sand and gravel of which the material after placement shall contain from 30 to 60 percent by weight retained on a ¼-inch mesh screen, and no stones shall be larger than 6 inches. Of the material passing the ¼-inch mesh screen, not more than 20 percent shall pass a No. 200 mesh screen. Samples of proposed material shall be submitted as stated in paragraph 4-06(b)).

(c) Measurement and Payment. - Measurement of sand and gravel backing material will be made between the lines indicated on the drawings, or as modified by the contracting officer. Payment for furnishing and installing backing material, regardless of source, (See paragraph 1-16) will be made at the contract unit price per cubic yard for "Sand and Gravel Backing." (See also paragraph 2-08(g)).

4-08. STONE PROTECTION.

(a) Classification. - All rock for the stone protection for the embankments shall be sound, durable rock, other than shale, and as approved by the contracting officer, obtained from the required excavation. Riprap shall be composed of the following two classes of material:

(1) Riprap Class A. - Class A riprap shall be clean and rough, and the least dimension of any stone shall be not less than one-third its greatest dimension. Eighty percent of the rock must weight over 500 pounds and shall graduate with fair uniformity to a minimum weight of 200 pounds.

(2) Riprap Class B. - Class B riprap shall consist of clean stones and boulders removed from the compacted earth fill material and rock obtained from the required excavations, other than shale. This riprap shall consist of rocks weighing in general not over 250 pounds, of which not more than 10 percent of the whole shall be formed of pieces weighing less than 15 pounds which shall be well distributed throughout the mass.

(3) Rock Fill. - Rock fill shall consist of stones and boulders removed from the compacted earth fill material and rock obtained from the required excavation, other than shale. This rock fill shall consist of rocks weighing in general not over 1000 pounds, of which not more than 10 percent of the whole shall be formed of pieces weighing less than 15 pounds which shall be well distributed throughout the mass.

(b) Placement. - Stone protection shall be dumped in the sections to the lines and grades shown on the drawings or as directed by the contracting officer. The different sizes of each class shall be well distributed

within the section. Care shall be taken in dumping and placing not to disturb the underlying fill. The riprap forming the slope of the dikes shall be placed in approximately horizontal layers not exceeding 3 feet in thickness as the compacted earth fill progresses, and shall be kept substantially the same level as the compacted earth fill. Any change in the slopes of the compacted earth fill including slides and washouts shall be repaired by the contractor as directed by the contracting officer at no cost to the Government. At the end of a working season for placing compacted earth fill, and dumped riprap sections shall be complete. In the areas where Class B dumped riprap will form the final surface, such hand placing of the finished rock surface will be required as will insure a reasonably smooth and continuous surface to the slope lines showns on the drawings or as modified by the contracting officer with a tolerance not exceeding + 9 inches.

(c) Measurement and Payment.- Measurement for stone protection in the dumped section will be made in the embankments only between slope lines and grade lines shown on the drawings or as modified by the contracting officer for the three classes of stone protection. Payment will be made at the contract unit prices per cubic yard for "Riprap, Dumped; Class A", "Riprap, Dumped; Class B", and "Rock Fill" which will include payment for the selection of the materials, placing, and all other work required for the completion of the riprap and rockfill sections in accordance with three specifications.

4-09. SEEDING. -

(a) Preparation of Seed Bed. -

(1) The areas indicated on the drawings or required by the contracting officer shall be seeded. Prior to fertilizing and seeding, the areas shall be harrowed or raked until the soil has become loosened and pulverized. All sticks, litter, roots, weeds, stones larger than 1 inch in diameter and other objectionable materials shall be removed to a depth of 2 inches. The surface of all seed areas shall be trimmed and raked to conform to finished grades, after which the soil shall be ferilized as specified below. Immediately before sowing the seed, the surface of the seed bed shall be sprinkled, if necessary, and raked to a depth of 3/4 of an inch. The raking shall be done in a direction parallel to the contour lines of the slopes (not uphill or downhill).

(2) Method of Fertilizing. - Prior to seeding, fertilizers shall be uniformly spread in a manner satisfactory to the contracting officer. The seed beds shall be fertilized with 1,000 pounds of 20% superphosphate, and 200 pounds of sulfate of ammonia to the acre. In place of the superphosphate, 330 pounds of T.V.A. metaphosphate to the acre may be used.

(b) Seeding. - The quantity and types of seeds specified below shall be sown on prepared seed beds in a manner satisfactory to the contracting officer. The mixtures shall be sown at the earliest date possible between May 1 and September 1. The seed mixtures shall be sown by a mechanical hand seeder or drill. Whenever practical, the mixtures shall be sown in two applications, one-half the seed while the sower is travelling in one direction, and the other half sown while travelling at right angles to the first. The oats or rye shall be sown separately and prior to the remainder of the seed mixture. If oats or rye is sown on the surface, the seeds shall be covered by raking to a depth from 1 to 1½ inches unless the oats or rye are sown with a drill. After all the seed is sown, the seed bed shall be lightly raked with iron rakes, and then rolled with

a lawn roller in a manner satisfactory to the contracting officer.

(1) Seed Mixture. - The seed mixtures shall consist of the seeds specified in the table below. When directed by the contracting officer, the seed mixtures may be varied to suit special conditions of soil peculiar to the areas to be seeded. The seed furnished shall be of the previous year's crop and in no case shall the weed content exceed 1% by weight.

Seed Mixture for Seed Bed not Containing topsoil

Kind of Seed	% Purity	% Germination	Amount lbs. per acre
Sweet Clover	99	85	5
Alfalfa	98	85	2
Black Medic	95	80	1
Orchard Grass	97	90	3
Timothy	98	85	3
Redtop	98	90	4
Ladino Clover	97	90	1
			19
Oats (Seeding prior to July 15),	99	90	30
Rye (Seeding after July 15)	99	90	35

(2) Inoculation. - The alfalfa, black medic, sweet clover, and ladino clover seeds shall be inoculated with pure cultures of nitrogen fixing bacteria. Inoculants shall consist of pure bred soil or sand cultures, not more than one year old, and shall meet the approval of the New York State Department of Agriculture and Markets. The inoculants shall be mixed with the seed according to the vendor's instructions. After the mixture is dried, it shall be mixed with the grass seeds. All mixing, drying and storing shall be done in the shade. The seed mixture shall be applied to the seed bed within 72 hours after the legume seeds are inoculated.

(c) Maintenance and Reseeding. - The contractor shall maintain the areas sown with the above seed mixture until all work on the contract has been completed and accepted by the contracting officer. The maintenance shall consist of refilling rain washed gullies, reseeding, mowing, watering during periods of drought, and other similar operations when required by the contracting officer. The contractor may, if he desires, protect slopes against erosion until seeding becomes established by spreading on the surface about four tons of straw to the acre.

(d) Measurement and Payment. - Measurement for seeding will be made by the acre for the area within the line shown on the drawings or as modified by the contracting officer. The contract unit price shall include payment for all work in connection with furnishing and sowing all necessary seed, raking and rolling the seeded areas, preparing the seed beds, furnishing and placing all necessary fertilizer, and maintaining all seeded areas. Payment for seeding all seed beds will be made at the contract unit price per acre for "Seeding."

4-10. PROTECTION OF GAGES, PIEZOMETERS, AND PRESSURE CELLS. In order to enable observations to be made during and after construction of the work required under the contract, the Government will install with its own forces a number of devices in and on the dike fills to consist of gages, piezometers, and pressure cells. The contractor shall conduct his operations in such a manner that these devices and appurtenances will not be damaged.

Fill around pipes and bars installed in and on the dike fills shall be placed and compacted by the contractor to the density of the surrounding compacted fill in the manner specified in paragraph 4-04 herein. Separate payment will not be made for such protection and special measures required in connection with gages, piezometers, and pressure cells and their appurtenances installed by the Contracting Officer.

SECTION V

CONCRETE

5-01. COMPOSITION. - Concrete shall be composed of cement, fine aggregate, coarse aggregate and water so proportioned and mixed as to produce a plastic, workable mixture in accordance with all requirements under this section and suitable to the specific conditions of placement.

5-02. CLASSIFICATION.

(a) Designation. - Except where required to meet special conditions, all concrete shall be Class "A", Class "B", or Class "C" in accordance with the conditions of application and the proportions of materials and strengths required.

(b) Class "A" concrete shall be used for all walls and slabs not thicker than three feet; pilasters, columns and beams in conjunction therewith; for the slabs spanning ice sluices, and as otherwise indicated on the drawings or directed by the contracting officer.

(c) Class "B" concrete shall be used in the heavy sections of the power house walls, above elevation 179, and elsewhere as directed by the contracting officer. In general Class "B" concrete will be used in all reinforced portions of the structure not specifically designated as Class "A" or Class "C" concrete.

(d) Class "C" concrete shall be used for the mass sections of the structure as indicated on the drawings or directed by the contracting officer.

5-03. STRENGTH. - Test specimens of concrete will be 6" x 12" or 8" x 16" cylinders. Samples of concrete will be wet screened to remove aggregate greater than one-fourth the diameter of the test specimen, (See paragraph 5-10). The mixes will be designed to secure concrete having at least the following compressive strengths at the age of 28 days:

Class	Average for any 25 Consecutive cylinders	Minimum for any one cylinder
A	3400 lbs. per sq. in.	2600 lbs. per sq. in.
B	3000 lbs. per sq. in.	2200 lbs. per sq. in.
C	3000 lbs. per sq. in.	2200 lbs. per sq. in.

5-04. HIGH-EARLY-STRENGTH CONCRETE. - High-early-strength concrete made with high-early-strength Portland cement or other special cements, shall be used only when specifically authorized by the contracting officer. The 7-day compressive strength of concrete of any class, when made with high-early-strength cement, shall be at least equal to the specified minimum 28-day compressive strength for the same class made with standard cement. All provisions of these specifications, except for cement, shall be applicable to such concrete.

5-05. CEMENT AND AGGREGATES. - Cement, and fine and coarse aggregates will be furnished to the contractor by the Government in accordance with paragraph 1-10 of these specifications.

5-06. WATER. - The water used in mixing concrete shall be clean

and free from injurious amounts of oil, acid, alkali or organic matter.

5-07. STORAGE.

(a) Cement.

(1) Immediately upon receipt, at the site of the work, cement shall be stored in a thoroughly dry, weathertight, and properly ventilated building or bin with adequate provisions for the prevention of the absorption of moisture. Storage shall be such as to permit easy access for inspection and definite indentification of each shipment.

(b) Aggregates. - Each size of aggregate (see paragraph 5-08(f), shall be stored separately in a free draining stock pile or bin and in such manner as to avoid the inclusion of any foreign material. Stock piles of coarse aggregates shall be built in horizontal layers to avoid segregation.

5-08. PROPORTIONING.

(a) Basis. - All concrete materials will be proportioned so as to produce a workable mixture in which the water content will not exceed the maximum specified.

(b) Control. - The exact proportions of all materials entering into the concrete shall be as directed by the contracting officer. The contractor shall provide all equipment necessary to determine, record, and control positively the actual amounts of the various materials, including water, cement, fine aggregate, and each individual size of coarse aggregate, entering into the concrete. The proportions will be changed whenever, in the opinion of the contracting officer, such change becomes necessary to obtain uniformity and workability or the specified strength, and the contractor will not be compensated because of such changes.

(c) Measurement. - All materials shall be measured by weight. One bag of cement will be considered 94 pounds in weight and 1 gallon of water as 8.33 pounds.

(d) Cement Content. - The cement content for each cubic yard of concrete shall generally fall within the following ranges:

Class "A" 5.0 to 6.0 bags
Class "B" 4.0 to 5.0 bags
Class "C" 3.5 to 4.5 bags

For concrete deposited in water, the minimum cement content shall be 6.5 bags or 611 pounds to each cubic yard of concrete placed. The cement content shall be at all times subject to variation as deemed necessary by the contracting officer to attain the desired results.

(e) Water Content and Consistency of Concrete. -

(1) In calculating the total water content in any mix, the amount of moisture carried on the surfaces of the aggregate particles shall in included. The total water content per bag of cement for each batch of concrete shall not exceed the following:

Class "A" 5.5 gallons or 45.8 pounds
Class "B" 6.5 gallons or 54.1 pounds
Class "C" 8.0 gallons or 66.7 pounds

In all cases, however, the amount of water to be used shall be the minimum amount necessary to produce a plastic mixture of the strength specified and to the desired density, uniformity and workability. In

general, the consistency of any mix shall be that required for the specific placing conditions and methods of placement, and ordinarily the slump shall be between ½ inch and 2 inches for Class "B" and Class "C" concrete, and between 1½ inches and 3 inches for Class "A" concrete when tested in accordance with the current specifications for "Method of Test for Consistency of Portland Cement Concrete," of the American Society for Testing Materials.

(f) Aggregate Content. - The total volume of aggregates to be used in each cubic yard of concrete shall be that necessary to produce a dense mixture of the required workability as determined by the contracting officer. The individual mixes will be based upon securing concrete having suitable workability, density, impermeability, and the required strength, without the use of an excessive amount of cement.

(1) Coarse Aggregate.

For Class "A" concrete the maximum size aggregate shall be not more than 1½ inches, and may be limited to 3/4 inch for the smaller structural members, depending on the conditions of placing.

For Class "B" concrete the maximum size aggregate shall be not more than 3 inches.

For Class "C" concrete the maximum size aggregate shall be not more than 6 inches.

Specified sizes shall be delivered separately to individual proportioning hoppers in accordance with the following:

a. 3/16" to 3/4"
b. 3/4" to 1½"
c. 1½" to 3"
d. 3" to 6"

(2) Fine Aggregate. - The fine aggregate will consist of natural sand or crushed stone sand and in either case will be furnished in one size graded so that at least ninety-five percent will pass a No. 4 square mesh sieve.

5-09. MIXING AND PLACING.

(a) Equipment. - The contractor shall provide at the site of the work a modern and dependable batch-type mixing plant with a minimum capacity of 2000 cubic yards of concrete per 8 hours. The plant shall include not fewer than 3 complete mixers of equal capacity with separate power plants. The equipment shall provide adequate facilities for the accurate measurement, record, and control of each of the materials entering the concrete. The complete plant assembly including provisions to facilitate the inspection of operations at all times and the adequacy and dependability of each of its parts, shall be subject to the approval of the contracting officer, and shall conform to the following requirements:

It shall be capable of ready adjustment for compensating for the varying moisture content of the aggregates and for changing the proportionate batch weights.

It shall be capable of controlling the delivery of each material to within 1 percent by weight of the designated amounts.

It shall be arranged to permit the convenient removal of material in excess of the specified tolerances, and acceptable facilities shall be provided for readily obtaining representative samples from the batches for test purposes.

Each weighing unit shall include a visible springless gage which

will register the scale load at any stage of the weighing operation from zero to full capacity.

Insofar as practicable, each dial and water-measuring device shall be in full view of the operator and the weighing equipment shall be arranged so that the operator may conveniently observe the operation of the bin gates and also the materials discharged into the mixer hopper.

The accuracy of the weighing equipment shall conform to the requirements of the U. S. Bureau of Standards. The contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device and shall make periodic tests, in the presence of a Government inspector, in such a manner and at such intervals as may be directed by the contracting officer; provided, that unless otherwise directed by the contracting officer, such check tests of equipment in operation shall be made at least once every two weeks. After completion of such check tests the contractor shall make such adjustments, repairs, or replacements as the contracting officer may consider necessary to secure satisfactory performance.

The plant shall include a device for accurately measuring and indicating the quantity of water entering the concrete and the operating mechanisms must be such that leakage will not occur when the valves are closed. The filling and discharge valves for the water tank shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed.

It shall include a device for accurately and autometically measuring and indicating the time of mixing, which shall be interlocked to prevent the discharge of concrete from the mixer before the expiration of the mixing period.

It shall include a device for recording and indicating the number of batches handled.

Each set of units for measuring cement and mixing water delivered to one or more mixers shall be provided with an accurate combined autographic recorder for making a continuous visible record on a single chart of the measurement of all materials introduced into each batch, and of the consistency of the concrete during the mixing process. The recorder shall be housed completely, shall be capable of being locked, and shall be placed in a position convenient for use by the plant operator. The recorder paper furnished shall be ruled and printed so that each graph will be identified permanently and so that quantities and time may be read without scaling or calculation. Suitable means shall be provided to insure proper alignment, rate of travel, and tautness of the paper without wrinkling. The recording equipment shall include facilities for automatically registering on the chart the time of day at intervals of not more than 15 minutes and shall be designed for simplicity in operation and maintenance.

Each mixer shall be equipped with an efficient recording consistency meter or provided with equally suitable equipment or means satisfactory to the contracting officer for indicating concrete consistency and recording it on the combined autographic recorder chart. The sensitivity and range of the consistency meters shall be such that the effect of a change in slump of one inch shall be readily discernible to the operator, as determined by the contracting officer. The contractor shall furnish satisfactory evidence that the consistency meters which he proposes to use are adapted to the type of drum and loading of the

mixers with which they are to be used. If the mixers are provided with consistency meters operating on the principle of measuring electrical input to the mixer motors, adequate means shall be provided for eliminating errors due to operating the motor from a variable-voltage supply source, with resultant changes in motor input which are not caused by changes in concrete consistency. If the contractor proposes to use means for the partial elimination and compensation of these errors, such means shall be subject to the approval of the contracting officer and the residual errors shall not exceed one percent of the values being measured. Errors in registration of concrete consistency caused by variable friction in the mixer equipment shall be eliminated or minimized by providing adequate anti-friction bearings and lubrication or by other means satisfactory to the contracting officer. All graphic charts recorded in accordance with this paragraph shall become the property of the Government. The air temperature in the mixing plant shall be maintained above 50 degrees F.

(b) Mixing Time. - The minimum time for mixing each batch, after all materials are in the mixer, shall be as follows:

1/2-cubic yard mixer, or small	1-1/4 minutes
3/4 to 1½ cubic yard mixer	1-1/2 minutes
1½ to 3 cubic yard mixer	2 minutes
Larger than 3 cubic yard	2½ minutes

The mixer shall revolve at a uniform speed, a minimum of 12 revolutions per minute after all materials have been placed in it. Neither speed of mixer nor volume of batch shall exceed those recommended by the manufacturer. Excessive overmixing, requiring additions of water to preserve the required consistency, will not be permitted. Should any mixer at any time produce unsatisfactory results its use shall be promptly discontinued until it is repaired or replaced.

(c) Conveying. - Concrete shall be conveyed from mixer to forms as rapidly as practicable, by methods which will prevent segregation or loss of ingredients. It shall be deposited as nearly as practicable in its final position. Chutes used shall be such that the concrete slides in them and does not flow. Chutes with a flatter slope than 1 on 2 will not be permitted. There shall be no free vertical drop greater than 5 feet except where specifically authorized by the contracting officer.

Methods of conveying concrete to any part of the structure by which the concrete is loaded into chutes, belt conveyors, or other similar equipment and carried in a thin, continuously exposed flow, to the forms, will not be permitted except for very limited or isolated section of the work, and then only when approved in writing by the contracting officer.

Concrete may be transported by pumping, provided there is no objectionable segregation between the mixing plant and the point of placement. When this method is adopted, the contractor shall submit a plan of the layout, together with an outline of methods for receiving, handling and placing the concrete, the slump and the maximum size of aggregate that can be handled. This plan of operation will be either accepted by the contracting officer or returned to the contractor for revision prior to acceptance. Concrete shall not be dropped from the end of the pipe into place but shall be led into place by spouts, troughs, or elephants trunks.

Placing of concrete in the mass sections of the structure shall, in general, be done by means of bottom-dump buckets of sufficient size to

handle the full capacity of one mixer. The design of the buckets shall be subject to the approval of the contracting officer, and shall be such as to permit close regulation of the amount of concrete to be deposited in each dumping position. It is contemplated that the full capacity of a bucket may be deposited in one operation where this has no objectionable effect on the placement of concrete, but near forms and around embedded items or elsewhere as directed by the contracting officer, the discharge shall be controlled so that the concrete may be effectively compacted into layers not exceeding 18 inches in thickness with a minimum of lateral movement and accompanying tendency for segregation and the formation of rock pockets.

(d) Placing.

(1) Concrete shall be placed before initial set has occured and, unless otherwise authorized by the contracting officer, before it has contained its water content for more than 45 minutes.

(2) Concrete when deposited in the forms shall have a temperature of not more than 75 degrees F. and not less than 40 degrees F. However, when the temperatures of the materials are such that the temperature of the fresh mixed concrete is 55 degrees F. or more, the mixing water shall be cooled to a temperature of 35 degrees F., and only aggregates taken from the coolest portions of the stockpiles shall be used. Any heating, cooling, refrigerating, or other operations necessary in order to produce a concrete having a temperature within the above specified temperature limits, (40° degrees F. to 75 degrees F.), shall be done by the contractor and the cost thereof shall be included in the unit prices bid in the schedule for the various classes of concrete.

(3) Unless otherwise specified, all concrete shall be placed in the dry upon clean, unfrozen, damp surfaces, free from running water, and never upon soft mud, dry porous earth, or upon fills that have not been subjected to approved rolling or tamping until optimum compaction has been obtained.

(4) Rock surfaces upon which concrete is to be placed shall be approximately horizontal or stepped, and shall be clean, solid, and free from oil, running water, mud, objectionable coatings, debris and loose, semi-detached, or unsound fragments and shall be sufficiently rough to assure satisfactory bond with the concrete. Immediately before concrete is placed, all such rock surfaces shall be cleaned thoroughly by the use of high velocity air-water jets, wet sandblasting, stiff brooms, picks, or other effective means satisfactory to the contracting officer. All pools of water shall be removed from depressions in order to insure proper bonding of the fresh concrete to the rock surfaces and no inflow of water into the foundation will be permitted. All necessary installations of riser pipes, headers, sand drains, and other installations necessary to produce a foundation free of running or standing water shall be installed by the contractor and so welded or otherwise securely fastened in place as to prevent their being jarred loose by concrete placement. No separate payment will be made for such installations. No wooden plugs or other organic materials shall be placed permanently in any foundation. All absorptive surfaces shall be thoroughly wetted for 48 hours and spread with a layer of mortar about 1/2-inch thick immediately before the concrete is placed. The mortar shall be of the same cement-sand ratio as used in the concrete.

(5) The layout of all monoliths shall be as shown on the drawings or as directed or approved by the contracting officer before concreting is commenced.

(6) All concrete shall be deposited in approximately horizontal layers, unless otherwise specifically authorized or directed by the contracting officer, and the concreting shall be carried on as a continuous operation, as far as practicable, until the placing in the course, section, panel or monolith is completed. During one pour concrete must be covered with fresh concrete within 45 minutes to one hour, depending on cement used. Lifts of mass concrete in the dam and training walls shall not exceed 5 feet in thickness except as shown on the drawings, and a minimum of 120 hours shall elapse between the finishing of one such lift and the starting of the next. In general a minimum of 24 hours shall elapse for each foot of course thickness between the finishing of one lift and the starting of the next. The first two to four courses starting from the foundation and from lifts which have been in place longer than 15 days shall be limited to a maximum height of 2 to 3 feet, as determined by the contracting officer.

Other construction lifts shall generally have a minimum thickness of 4 feet, and a maximum thickness of 12 feet. In walls of buildings, courses shall terminate at the tops and bottoms of the door and window openings.

(7) In dropping concrete through reinforcement, care shall be taken that no segregation of the coarse aggregate occurs. On flat surfaces where the congestion of steel near the forms makes placing difficult, a mortar of the same cement-sand ratio as is used in the concrete shall be first deposited to cover the forms.

(8) All top surfaces not covered by forms and which are not to be covered by additional concrete or backfill shall be carried slightly above grade and struck off by a board screed (see paragraph 5-11(a) except that top surfaces of walls and piers not covered by forms and which are not to be covered by additional concrete or backfill when poured in excess of 10 feet in height in one pour, shall be carried not less than 2 inches above the specified finished elevation and struck off by a board screed.

(e) Vibrating. - Concrete shall be placed with the aid of mechanical vibrating equipment as approved by the contracting officer.

(1) Internal vibrators shall be used in all sections 10-inches or more in width or which are sufficiently large to accomdate them. External vibration shall be used when directed by the contracting officer where internal vibration can not be used.

(2) Vibrators shall be of sturdy construction, adequately powered and capable of transmitting to the concrete not less than 5,000 impulses per minute when operating under load (immersed in concrete). The frequency of vibration shall be subject to proof by measuring the impulses radiated by the vibrator, when operating in concrete designed for the project, by use of a Frahm vibrating-reed tachometer, or equal. The vibration shall be sufficiently intense to cause the concrete to flow or settle readily into place and show a visible effect over a radius of at least 18 inches in the concrete.

(3) A sufficient number of vibrators shall be employed so that, at the required rate of placement, vibration throughout the entire volume of each layer of concrete and complete compaction are secured. At least one extra vibrator shall be constantly on hand at each point of placement (monolith) for emergency use.

(4) Form vibrators, where used, shall be attached to or held on the forms in such a manner as to transmit the vibration to the concrete effectively and shall be raised in lifts as filling of the forms proceeds, each lift being not more than the height of concrete visibly affected by the vibration. They shall be placed horizontally at distances not greater apart than the radius through which the concrete is visibly affected.

(5) Internal vibrators shall be kept constantly moving in the concrete and shall be applied at points uniformly spaced not farther apart than the radius over which the vibrator is visibly effective. The vibrator shall not be held in one location long enough to draw a pool of grout from the surrounding concrete. Internal vibrators shall be applied close enough to the forms to vibrate the surface concrete effectively, but care shall be taken to avoid hitting the forms sufficiently to damage them.

(6) The vibration shall be such that the concrete becomes uniformly plastic and there shall be at least 10 seconds of vibration per square foot of surface of each layer of concrete, computed on the basis of the visibly affected radius, and taking overlapping into consideration.

(7) Vibration shall be supplemented by forking and spading by hand adjacent to the forms on exposed faces. The concrete shall be compacted and worked in an approved manner into all corners and angles of the forms and around reinforcement and embedded fixtures.

(f) Construction Joints. - Vertical joints shall be formed with tongue-and-groove keys at such locations and of such shapes and dimensions as shown on the drawings or as approved or directed by the contracting officer. The horizontal edges of each completed pour not required to be chamfered that are exposed to weathering shall be struck off level for a distance of about 6 inches back from the forms to provide an even and neat appearance between construction joints. Where required, dowel rods shall be used.

All concrete in vertical members shall have been in place not less than 12 hours, and longer if so directed by the contracting officer, before concrete in horizontal members resting thereon is placed. Haunches shall be considered as parts of horizontal members and shall be placed therewith.

After the top surface of a course is finally compacted, it shall be thoroughly protected from pedestrian traffic, materials being placed thereon, running water, or any activity upon the surface that might in any manner affect the initial setting of the concrete for a period of 4 to 20 hours as determined by the contracting officer. After the time required for initial set, the surface shall be washed with a high pressure air (air pressure capacity not less than 100 p.s.i.) and water jet to remove all laitance and to expose clean sound aggregate.

Immediately before placing is resumed in each succeeding course, all horizontal and approximately horizontal construction joint surfaces shall be washed with a high pressure air and water jet and scrubbed with steel brushes or brooms. Sand shall be added to the air-water jet when required to remove algae, stains and other substances injurious to bonding. After final cleaning and immediately before placing is resumed the surface shall be wetted and spread with a layer of mortar ½ inch thick. The mortar shall be of the same cement-sand ratio as the concrete.

Where fresh concrete is to be placed against smooth surfaces of previously placed concrete, the surface of the previously placed concrete shall be roughened by picking, or other means approved by the contracting officer, in order to secure adequate bond. No payment will be made for such roughening but the cost shall be included in the contract unit price for the class of concrete affected.

(g) In water. - When specifically authorized, concrete may be deposited in water having a temperature above 35 degrees F. The methods and equipment used shall be subject to the approval of the contracting officer. When deposited by the tremie method, the tremie shall be water-tight and sufficiently large to permit a free flow of concrete. The discharge end shall be kept continuously submerged in the concrete and the shaft kept full of concrete to a point well above the water surface. When the bottom-dump bucket method is used, the bucket shall not be dumped until after it has come to rest on the surface upon which the concrete is to be deposited. The bucket shall be provided with a suitable cover, and the bottom doors, when tripped, shall open freely. The bucket shall be completely filled and slowly lowered in order to avoid backwash, and when tripped, it shall be slowly withdrawn until entirely free of the concrete. With either method, concreting shall proceed without interruption until the top of the concrete is well above the water surface.

(h) Cold Weather. - Concrete shall not be placed when the ambient atmospheric temperature is below 35 degrees F. nor when the concrete is likely to be subjected to freezing temperatures before final set has occurred, unless specifically authorized by the contracting officer in writing. When so authorized, the materials shall be heated in such a manner that they will be free of ice, slush, snow, frozen lumps, etc., before entering the mixer. The temperature of the concrete when deposited in the forms shall be within the limits specified in paragraph 5-09(d)(2). All methods and equipment for heating shall be subject to the approval of the contracting officer.

(i) Hot Weather. - For concrete placed during the extremely warm summer months and otherwise, when directed by the contracting officer, the contractor shall take whatever measures are necessary in order to produce a concrete having a temperature below the maximum limit specified in paragraph 5-09(d)(2). The methods and equipment used shall be subject to the approval of the contracting officer.

5-10. TEST SPECIMENS.

(a) Number. - Test specimens, to determine whether the compressive strength of the concrete is in accordance with that specified in paragraph 5-03, will be taken by the Government inspector. At least 1 set of 3 specimens will be made for every major placement and, in general, for every 500 cubic yards of concrete place, but in any event, a sufficient number of specimens will be taken to give a comprehensive knowledge of the concrete in each section of the work.

(b) Method. - All specimens will be taken from the concrete in accordance with the current specifications of the American Society for Testing Materials. The specimens will be tested by and at the expense of the United States, either in its laboratory or in that of a recognized commercial testing agency.

(c) Six Inch Cores for Testing. - The contracting officer may require that concrete cores 6 inches in diameter be cut from the concrete in the finished structure, for the purpose of testing, as specified in paragraph 3-14.

5-11. FINISHING

(a) General. - Immediately after placement, the concrete shall be properly forked back along the faces of all forms by the use of concrete forks or spades and then re-vibrated unless otherwise specifically authorized or directed by the contracting officer. The surface of concrete finished against forms shall be smooth, dense, and free from rock pockets. Immediately upon the removal of forms, all unsightly ridges or lips shall be removed and undesirable local bulging on exposed surfaces shall be remedied by tooling and rubbing to the satisfaction of the contracting officer; all holes left by the removal or omission of tie rods, and all similar voids unless otherwise directed by the contracting officer shall be neatly filled with cement mortar mixed in the same proportions as the original mix, provided that wherever practicable mortar which has been mixed and allowed to stand for one hour shall be used and placed as directed by the contracting officer. Defective concrete shall be repaired by cutting out the unsatisfactory material and placing new concrete which shall be formed with keys, devetails, or anchors to attach it securely to the otherwork. This concrete shall be drier than the usual mixture and shall be thoroughly tamped into place. All finishing, tooling, rubbing and filling of the rod holes and all patching of exposed surfaces must be performed immediately after forms are removed and the succeeding course of concrete shall not be placed until the exposed surfaces of the preceding lifts have been finished to the satisfaction of the contracting officer. All horizontal surfaces of concrete, not covered by forms, that are not to be covered by additional concrete or backfill, shall have a wood float finish without additional mortar, and shall be true to elevations as shown on the drawings. Care shall be taken to see that all excess water is removed before making this finish. Other surfaces shall be brought to the specified finished elevation and left true and regular as approved by the contracting officer. Where considered necessary by the contracting officer, or where indicated on the drawings, joints shall be carefully made with a jointing tool.

Every precaution shall be taken by the contractor to protect finished surfaces from stains or abrasions. No fire shall be permitted in direct contact with any concrete at any time. Concrete surfaces, or edges likely to be injured during the construction period, shall be properly protected by leaving the forms in place, or by erecting covers satisfactory to the contracting officer.

Concrete surfaces for all water passages, pier nosings and the scroll cases shall be finished with extreme care so that there are no projecting fins, pits or other defects that might interfere with the smooth flow of water.

(b) Monolithic Floor and Horizontal Surfaces. -

(1) Monolithic concrete floor finish shall be of the same mix as the base of the slab, the full depth being placed at one time. The surface shall be screeded, floated with a wood float in a manner to thoroughly compact it, and then steel-troweled to a smooth finish. Troweling shall be the minimum amount consistent with obtaining a smooth dense surface and shall not be done until the concrete has hardened sufficiently to prevent excess fine material from being worked to the surface.

(2) The floor finish shall not be cut through or lined off, except where so indicated on the drawing details, to follow.

(3) Stair treads shall be brought to a smooth, hard finish. Where metal stair treads are used, the concrete shall be carefully and thoroughly worked into place around the treads. All treads shall be true to line and grade.

(4) Concrete slabs over which built-up roofing is to be applied and slabs which are to be covered with membrane waterproofing shall be struck off true to grade, and floated to smooth surfaces suitable for application of roofing.

(5) Treatment of the top surfaces of removable concrete slabs shall be similar to the floor in which they are to be located.

(6) Curing. - Concrete floor finish shall be covered with moist sand and cured for fourteen days, after which all sand or other covering shall be removed.

(7) Protection. - The contractor shall provide proper protection for floors to prevent damage of any kind prior to completion of all work under the contract.

(8) Measurement for Payment. - Payment for monolithic concrete floor finish will be based on the actualarea of surface installed making no deductions for areas of less than 10 square feet.

(9) Payment. - The cost of all labor, plant and materials (except materials specified to be furnished by the Government) required to finish all monolithic concrete floors as specified or directed, shall be included in the contract price, per square foot, for "Monolithic Concrete Floor Finish."

5-12. CURING.

(a) General. - Before actual concrete placement begins, the contractor shall have on hand and ready to install all equipment needed for adequate curing and protection of the concrete.

(b) Warm Weather. - All concrete shall be adequately protected from injurious action by the sun. Fresh concrete shall be protected from heavy rains, flowing water, and mechanical injury. All concrete shall be kept wet for a period of not less than 14 days by covering with water, or with an approved water-saturated covering or by a system of perforated pipes or mechanical sprinklers, or any other approved method which will keep all surfaces continuously (not periodically) wet. Where wood forms are left in place for curing, they shall be kept wet at all times to prevent opening at the joints and drying out of the concrete. Water for curing shall conform to the requirements of paragraph 5-06, and shall be generally clean and entirely free from any elements which, in the opinion of the contracting officer, might cause staining or discoloration of the concrete.

(c) Cold Weather. - Concrete when placed during cold weather shall be kept moist and provided with adequate protection, subject to the approval of the contracting officer, so that the air in contact with the concrete will be maintained at temperatures between 50 degrees F. and 70 degrees F. for at least the first 5 days. For massive section, where the atmospheric temperatures are sufficiently low, in the opinion of the contracting officer, to cause excessively rapid cooling and contracting of the exterior surfaces, the period for maintaining the temperature of the air in contact with theconcrete between 50 and 70 degrees F. may be required to extend for 14 days. In extremely cold weather, the removal of temperature protection shall be done gradually

so that the temperature of the air surrounding the concrete is reduced to the outside air temperature at a rate not faster than 5 degrees F. in any one hour, or 50 degrees in any 24 hour period. Salt or ther chemicals shall not be admitted into the mixture to prevent freezing.

(d) Discoloring. - When absorptive form lining is used, measures must be taken to prevent the staining of the surfaces of already-placed concrete by drainage from the new pour. The adequacy of such measures are to be subject to the approval of the contracting officer.

5-13. FORMS.

(a) Materials. - Forms shall be of wood, steel or other approved material, except that the sheeting for all exposed surfaces shall be tongue-and-groove lumber of uniform width unless otherwise specifically authorized. Forms of like character shall be used for similarly exposed surfaces in order to produce a uniform appearance. The type, size, shape, quality and strength of all materials of which the forms are made and the design of the forms shall be subject to the approval of the contracting officer.

(b) Construction. - Forms shall be built true to line and grade, and shall be mortar-tight and sufficiently rigid to prevent displacement or sagging between supports. Where forms for continuous surfaces are placed in successive units, care shall be taken to fit the forms tightly over the completed surface so as to prevent leakage of mortar from the concrete and to maintain accurate alignment of the surface. Responsibility for their adequacy shall rest with the contractor. Their surfaces shall be smooth and free from irregularities, dents, sags, or holes when used for permanently exposed faces. Bolts and rods used for internal ties shall be so arranged, that, when the forms are removed, all metal will be not less than 2 inches from any concrete surface. Bolt holes shall be reamed with a suitable toothed reamer so as to leave the surfaces of the holes clean and rough and shall be filled with mortar as specified in paragraph 5-11(a), immediately upon removal of the forms. Wire ties will not be permitted without the approval of the contracting officer, and at no time where the concrete surface will be exposed to weathering and where discoloration will be objectionable. All forms shall be so constructed that they can be removed without hammering or prying against the concrete. Unless otherwise indicated, suitable moldings shall be placed to bevel or round exposed edges, at expansion joints and/or any other points as may be required by the contracting officer.

(c) Curved Forms. - Curved or special forms shall be of a character that will result in smooth concrete surfaces and shall at all times be subject to the approval of the contracting officer. The surfaces shall be faced with dressed and matched lumber or other approved material. Forms shall be so designed that they will not warp or spring out of shape during their erection or the placing and vibrating of concrete.

(d) Coating. - Forms, except those lined with absorptive form lining, shall be coated with a non-staining mineral oil which shall be applied shortly before the concrete is placed.

(e) Removal. - Forms shall not be removed without the approval of the contracting officer, and all removal shall be accomplished in such manner as will prevent injury to the concrete. Forms shall not be removed before the expiration of the minimum number of

days indicated below, except when specifically authorized by the contracting officer. When, in the opinion of the contracting officer, conditions on the work are such as to justify it, forms may be required to remain in place for longer periods.

Arches, beams and slabs	14 days
Columns	7 days
Walls and vertical faces	2 days

(f) Absorptive Form Lining. - In addition to the requirements for work specified above, the forms for all exterior surfaces of the structure that will be visible above low head or tail water and all interior wall surfaces that will be visible in the finished structure (not covered with plaster or other treatment under another contract) and the curved surfaces of the ice sluices shall be constructed of matched lumber, approved by the contracting officer, and lined with absorptive lining. The absorptive form lining shall be capable through its absorptive capacity of eliminating voids, pits and other common defects from the surface of the concrete placed against it. The form lining shall be highly absorptive to air and water and shall possess surface characteristics such as will result in a dense concrete with a satisfactory surface texture, and the minimum amount of sticking of the lining upon removal of the forms. The lining shall be readily adaptable to cutting, fitting, and any other operation necessary in connection with its use. The lining itself, and any coating or treatment employed in its manufacture, shall be such as will not create discoloration or interfere with the normal chemical reactions of the cement in the concrete. The type of lining shall be subject to the approval of the contracting officer. Tests shall be made by the contractor of all proposed absorptive lining as directed by the contracting officer. These tests shall include the use of absorptive form lining on concrete surfaces which will be later covered by backfill. Samples shall also be furnished to the Government for laboratory tests, before approval of any type of lining by the contracting officer. Horizontal joints will not be permitted in absorptive form lining except at horizontal construction joints in the concrete unless otherwise directed or approved by the contracting officer. Other joints in absorptive form lining shall be made only where directed or approved by the contracting officer. For cutting and trimming the absorptive lining, the contractor shall use tools which are well adapted for this work and are maintained in such condition that smooth edges will be produced. The joints between the sheets of absorptive form lining shall be fitted smoothly and accurately, and patching of the sheets of absorptive form lining will not be permitted. At joints, the edges of the form lining shall be in contact but shall not be pressed tightly together. Absorptive form lining shall be attached to the forms with only a sufficient number of nails or other means to hold the lining snugly in contact with the surface of the forms, and free from bulges and other imperfections that might cause unevenness or roughness of the concrete surfaces. Nails shall be driven so that the under side of the nailheads will be flush with the surface of the absorptive lining, and care shall be taken not to make dents in the surface of the lining with hammers or in any other manner. After the absorptive lining has been nailed in place, the joints shall be rubbed with a smooth tool to make the joints smooth and to press down any projecting fibers. In tightening the form

anchors where absorptive form lining is in contact with the face of a previous lift, sufficient pressure shall be applied to compress the lining at the surface of contact so as to compensate for the reduction in thickness of the lining not in the surface of contact which will be caused by the pressure of the freshly placed concrete. Insofar as practicable, the contractor shall avoid splashing mortar or concrete on the absorptive lining and shall remove, without damage to the lining, such coatings as have set or become dry before the concrete is placed against the lining. Absorptive form lining of fibrous materials shall be used only once unless it can be demonstrated, to the satisfaction of the contracting officer, that re-use is practical. After use, form lining shall be removed from the site of the work or disposed of as approved by the contracting officer. Forms lined with absorptive lining shall, in general, be removed or loosened early enough to avoid difficulty from sticking; except, the form shall be allowed to remain in place for a sufficient length of time to provide adequate support for the concrete, as determined by the contracting officer. Fibers from the lining which adhere to the concrete when the forms are removed, shall be removed without damage to the concrete, by brushing or other suitable means, as approved by the contracting officer. At all times subsequent to delivery of the absorptive form lining and prior to the placing of concrete against the lining, the contractor shall take all precautions necessary to protect the lining from becoming damp or wet to such an extent as to damage the material or to reduce its effectiveness as an absorptive medium. Particular care shall be exercised to protect absorptive form lining during clean-up operations, and temporary protection of such lining will be required. The use of absorptive form lining which has become wet or which contains visible external defects such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances or indentations, will not be permitted.

(g) Special Forms for Ceilings. - The bottoms of poured concrete slabs and sides and soffits of beams, which will be visible in the finished structure, shall be lined with pressed wood, masonite board or plywood meeting with the approval of the contracting officer.

(h) Measurement for Payment. - Measurement for payment for forms and form lining shall be based on the contact area between the forms and the final outline of the concrete with no deductions for openings less than 30 square feet in area and with no addition for reveals or chases less than 3 inches in depth.

The warped faces of the downstream training walls shown on sheet 17 of the drawings will be included in the quantity of straight (not curved) forms.

(i) Payment. - The cost of all labor, plant and material necessary to furnish, place and remove all forms and form lining including supporting framework shall be included in contract unit prices, per square foot for:

(1) "Straight Concrete Forms"
(2) "Concrete Forms Curved One Way"
(3) "Concrete Forms Curved Two Ways"
(4) "Absorptive Form Lining"
(5) "Concrete Forms for Ceilings"
(6) "Concrete Forms for Construction Joints"

The outline, shape or size of the concrete spiral casing may be changed by the contracting officer well in advance of construction of that portion of the work, if found desirable from a hydraulic standpoint.

Should this change be made, the work will be paid for in accordance with the contract prices as included in the schedule, and the contractor will not receive any additional reimbursement therefor.

5-14. STEEL REINFORCEMENT.

(a) General. - The contractor shall furnish and install all steel reinforcement, including rods and fabric as required. The contract unit price per pound for "Reinforcing Steel" shall include all cost of furnishing, cutting and bending, cleaning, proper storage straightening, if necessary, and complete installation. All reinforcement shall be, when surrounding concrete is placed, entirely free from loose scale, dirt, grease or other coating which might destroy or reduce its bond with the concrete. All placing shall be in accordance with drawings furnished or approved by the contracting officer.

(b) Cutting and Bending. - Steel reinforcement shall be mill bent, but any miscellaneous bending that may be required at the site shall be in accordance with standard approved practice and by approved machine methods. Bar lists and bending schedules shall be as shown on detail drawings to be furnished by the contractor and approved by the contracting officer (See paragraph 1-04(c).

(c) Quality. - The steel reinforcing shall conform to the requirements of paragraph 6-04.

(d) Minimum Spacing of Rods. - The spacing of rods shall be as directed and the clear distance between parallel rods shall not be less than 1½ times the diameter of round rods, or twice the side dimensions of square rods, but in no case shall the clear spacing between the bars be less than 1½ times the maximum size of the coarse aggregate used in the concrete, unless specifically authorized by the contracting officer.

(e) Relation of Rods to Concrete Surfaces. - Except where otherwise indicated, reinforcement shall be placed as follows:

(1) All main reinforcement in massive concrete sections shall be placed not less than 4 inches from any concrete surface, unless otherwise specifically indicated or authorized.

(2) All main reinforcement in walls and slabs of buildings exposed to the weather and in fire-resistant construction, shall be placed not less than 1 inch from the surface in walls and slabs, 1½ inches in floor beams, and 2 inches in girders and columns. In interior flat slab construction, the minimum cover may be reduced to 3/4 inch. For interior work where fire hazard does not exist, the main reinforcement shall be placed not less than 3/4 inch from the surface in walls and slabs, 1 inch in floor beams, and 1½ inches in girders and columns.

(3) The covering of stirrups, spacer rods, and similar secondary reinforcement may be less than the above dimensions by the diameter of such rods. The above dimensions shall be measured from the face of the reinforcement to the face of the forms.

(f) Splicing. - Where splices in reinforcement, in addition to those indicated on drawings or directed by the contracting officer, are necessary, there shall be sufficient lap to transfer the stress by bond. Rods shall be lapped not less than 40 diameters and splices shall be staggered. The lapped ends of rods shall be separated sufficiently or connected properly to develop the full strength of the rods. Ad-

jacent sheets of mesh reinforcement shall be spliced by lapping not less than 6 inches, the lapped ends being securely wired together. The expense caused by any laps other than those indicated on the drawings or directed to be placed by the contracting officer, which are provided for the convenience of the contractor, shall be borne by the contractor. The contractor may, at his option, weld by electric resistance welding any bars one inch square and larger, where the length of bars required is too long for convenient shipment, provided such work is done by welders qualified as specified in paragraph 7-07 (d)(1)a. The welds will be inspected and tested by the Government. Samples shall be selected for test as directed by the contracting officer, the number thereof not to exceed 5% of the total number of welds. The expense for all tests (but not inspection) shall be borne by the contractor.

(g) Supports. - All reinforcements shall be secured in place, true to the lines and grades indicated, by use of metal or concrete supports, spacers or ties as approved by the contracting officer. Such supports shall be of sufficient strength to maintain the reinforcement in place throughout the concreting operation, and shall be used in such a manner that they will not be exposed on the face of, nor in any way discolor nor be noticeable in the surface of the finished concrete. The cost of furnishing and placing all supports, spacers, ties and/or other devices required for reinforcement shall be included in the contract unit price for "Reinforcing Steel."

(h) Protection for Future Use. - Exposed reinforcement intended for bonding with future work shall be protected from corrosion by heavy wrapping of burlap saturated with bituminous material.

(i) Measurement and Payment for Steel Reinforcement. - Steel reinforcement will be paid for at the contract unit price per pound for "Reinforcing Steel." (See also paragraph 9-04(a). The weights for payment shall be based on the amount actually placed in accordance with the dimensions and details on the bar schedules as approved by the contracting officer. Unit weights used in determining computed weights will be as follows:

Size of Bars, Inches	Weight, Pounds per Foot
3/8 round	0.376
1/2 round	0.668
1/2 square	0.850
5/8 round	1.043
3/4 round	1/502
7/8 round	2.044
1 round	2.670
1 square	3.400
1-1/8 square	4.303
1-1/4 square	5.313
1-1/2 square	7.650

5-15. DOWEL BARS

(a) General. - Where required, dowel bars shall be placed in existing concrete work to anchor the new concrete to it. Holes shall be drilled into the existing concrete to depths as directed by the contracting officer, and the bars shall be grouted into these

holes sufficiently in advance of concreting operations so that the grout will be set prior to placing the new concrete.

The dowel bars shall be deformed steel reinforcing bars and shall conform to the provisions of paragraph 6-04; the grout shall conform to the provisions of paragraph 5-19.

(b) Measurement for Payment.

(1) Payment for holes drilled for installation of dowel bars shall be based upon the linear feet of holes drilled as measured after completion of drilling, inclusive of any "false" drill holes that may have been started and discontinued when striking encased reinforcing steel.

(2) The total weight of reinforcing bars that will be used as dowel bars shall be included in the quantity for which payment will be made under the item for "Reinforcing Steel."

(c) Payment. - The cost of all plant, labor and materials, (except those specified to be furnished by the Government) required to place dowel bars, as directed, shall be included in the contract price per lineal foot of hole for "Drilling Holes for, and Placing Dowel Bars."

5-16. EMBEDDED ITEMS.

(a) Before placing concrete, care shall be taken to determine that any embedded metal or other parts are firmly and securly fastened in place as indicated. They shall be thoroughly clean and free from coating, rust, paint, scale, oil, or any foreign matter. The embedding of wood in concrete shall be avoided whenever possible, metal being used instead. If wood is allowed, it shall be thoroughly wetted before the concrete is placed. Any air or water lines or other materials embedded in the structure as construction expedients shall conform to the above requirements and upon completion of their use shall be backfilled with concrete or grout as directed by the contracting officer. No payment will be made for such items nor for backfill of the items.

(b) For the placement of structural steel in concrete see Sections VII.

(c) Reglets. -

(1) Reglets, if used, shall be No. 24 gage steel cast into the concrete and thoroughly anchored, of size and shape suitable for their particular use. At breaks in level, the reglets shall overlap at least 6 inches and they shall be installed in long lengths with joints overlapped.

(2) The cost of all labor and material necessary to furnish and place all metal reglets as specified or directed by the contracting officer shall be included in the contract price, per linear foot, for, "Metal Reglets".

5-17. PRECAST CONCRETE SLABS. - Under this heading the contractor shall make and place in the structure all precast concrete slabs required, using Class "A" concrete.

The payment for precast slabs shall be included in the contract unit prices for the separate classes of work.

5-18. EXPANSION AND CONTRACTION JOINTS.

(a) General. - Expansion and contraction joints shall be constructed at such points and of such dimensions as may be indicated or required. The method and materials used shall be subject to the approval of the contracting officer and the materials shall conform to Federal Specifications wherever applicable. In no case shall corner protection angles or other fixed metals embedded in the concrete and bonded be continuous through an expansion joint.

(b) Built-up Joint Filler. - Joints between monoliths shall contain a built-up joint filler where indicated on the drawings and as described below unless otherwise directed by the contracting officer: in the area of the joint between the metal water stop and the upstream face of the structure: in areas of the joint between surfaces of the galleries and the surrounding metal water stops; and in other places, a strip 18 inches wide adjacent to final exposed surfaces. The filler shall consist of one thickness of 30 lb. asphalt-saturated roofing felt conforming to Federal Specification HH-F-191, for "Felt; Asphalt-Saturated, (for) Flashing, Roofing, and Water proofing, "Type 2, joined to the concrete on each face of the joint by a uniform trowelled layer of bituminous cement Type "B" (See paragraph 6-14(a).

(c) Preformed Expansion Joint Filler. - Preformed joint filler one-half inch thick, or thicker shall be used in the expansion joints where shown on detail drawing, or otherwise required by the contracting officer. It shall conform to the requirements of paragraph 6-13. Pieces of the joint filler which have been deformed, broken or otherwise damaged shall not be used. Care shall be taken in placing so that strips of the joint material will butt tightly against the adjoining one.

(d) Asphalt Filler for Joints. - An emulsified asphalt joint filler conforming to the requirements of paragraph 6-14(c) shall be used in the expansion joints of the penstock deck and in other joints above the preformed joint filler and elsewhere as indicated on the drawings or required by the contracting officer. The surfaces to be sealed shall be substantially dry and shall be thoroughly cleaned of all loose scale, dirt, and other foreign matter preparatory to pouring the joint filler. The asphalt to be used for capping or sealing the expansion joints is an emulsion and shall be mixed with clear cold water to the consistency necessary for proper application by trowelling. A block or form shall be used at each end to hold the material in the joint until it has set, and the filler shall be formed flush with the surface of the adjoining concrete or steel. Precautions shall be taken to prevent pouring any material on the exposed surfaces adjacent to the joints.

(e) Water Stops, Bituminous and Metal. - Water stops at the upstream face of the powerhouse at vertical joints shall be of copper strips backed up by six-inch diameter wells filled with special bituminous filler, type "C", containing a steam heating unit. Details will be shown on drawings to be issued later.

The six-inch wells shall be formed by halved concrete pipe on one side of the well. The halved concrete pipe shall be non-reinforced, and of bell and spigot pattern, and shall conform to Federal Specification SS-P-371. The minimum thickness of shell shall be one inch and depth of socket two inches. The halved or split faces shall be smooth and in one plane.

As the walls and mass sections progress in height, sections of the steam heating unit shall be installed in the wells, and the wells shall be filled solid with bituminous material. The special bituminous

filler, type "C" shall conform to the requirements of paragraph 6-14(b). After completion, each vertical joint shall be heated by steam until the bituminous material is melted, and additional bituminous material shall then be introduced under pressure until no more can be added under pressures up to 100 pounds per square inch or as directed by the contracting officer. This filler will be supplied through a 4-inch wrought iron pipe installed at an accessible location, as directed by the contracting officer. Inside this feeder pipe, and extending in a continuous circuit from the bottom to the top of the six-inch well, shall be placed the 3/4-inch wrought iron steam pipe for use as a heater coil to soften the bituminous filler. The 4-inch wrought iron pipes shall extend beyond the surface of the concrete and shall be fitted with steel flanges. The wrought iron steam pipes and 3/4-inch nipple for supplying bituminous material shall extend 2 inches beyond the flange on the 4-inch pipe and shall be threaded and capped. All wrought iron pipe shall be genuine wrought iron conforming to the requirements of paragraph 6-16.

The water stops shall be 16-ounce copper 24-inches wide conforming to the requirements of paragraph 6-09(a) and bent as will be shown on the drawings. The ends of the strip shall be lapped 1 inch and joined together and made watertight be brazing which shall be subject to the approval of the contracting officer. The bottom of each water stop at monolith contraction joints shall be embedded six inches in firm rock and the recess filled with mortar and the mortar allowed to harden before placing the first lift of the concrete. Immediately after removal of the form, the exposed metal water stops, concrete pipe and steam pipe shall be protected by boxes approved by the contracting officer.

Other water stops of 16-ounce copper conforming to the requirements of paragraph 6-09(a) and bent as will be shown on the drawings, shall be installed around gallery openings at contraction joints and elsewhere as indicated on the drawings, or as otherwise required.

(f) Measurement and Payment for Material in Joints. - Joint material shall be measured in place and shall include all labor, plant and material necessary to furnish and install the joints complete as specified, in accordance with the following contract unit prices:

(1) "Halved Concrete Pipe," per linear foot.
(2) "Copper Water Stops," per pound
(3) "Special Bituminous Filler, Type C" per cubic foot.
(4) "Wrought Iron Pipe and Fittings" per pound (See also paragraph 11-18

(g) Pressure Grouting Structure. -

(1) Grout Pipes. - Black steel pipe conforming to the requirements of paragraphs 6-15(a) and (b) shall be placed in the concrete for pressure grouting at such points as may be designated by the contracting officer. Ends of pipe at joint to be grouted shall be fitted with an approved sheet iron grout shield or box to permit entrance of the grout into the joint. Where required, to prevent loss of grout, the space adjacent to grout pipes shall be caulked with oakum or satisfactorily plugged, and grout stops shall be installed in the joints as directed.

(2) Payment for grout pipes. - The cost of all labor and material required to furnish and install all embedded grout pipes and connections as specified or ordered shall be included in the contract unit price per pound for "Grout Pipes and Connections" (See also paragraph 3-11(g)(1), which price shall include all necessary caulking,

grout shields and fittings, but not grout stops. Grout stops will be paid for at the contract unit price per pound for "Sheet Iron and Steel".

(3) Pressure Grouting. - Pressure grouting shall be done in the manner and with the equipment specified in paragraph 3-12(c) and (d) and at pressures as directed by the contracting officer.

(4) Payment. - Payment for pressure grouting in the structure will be made as specified in 3-12(e).

5-19. POURED GROUT.

(a) Materials and Placing. - The contractor shall mix and place all grout required to complete the work and not specifically included elsewhere. Grout shall be a mixture of cement, sand and water, of proportions as directed. The grout shall be placed in such a manner that the entire space being grouted will be completely filled, as directed by the contracting officer. Cement and sand for poured grout will be furnished by the Government, but the contractor shall screen the sand when necessary to remove the larger particles.

(b) Payment. - The cost of all labor, plant and materials (except those furnished by the Government) for pouring grout as specified or directed, shall be included in the contract unit price per cubic foot for "Poured Grout." (See also paragraphs 9-06 and 10-18)

5-20. SPECIAL GROUTING UNDER MACHINERY.

(a) Material. - Grout used under machinery and in other locations, when so directed by the contracting officer, shall contain special aggregates to prevent shrinkage. The proportion of materials and method of placement shall be as directed by the contracting officer. The metallic aggregate shall, when mixed with standard Portland cement and clean natural sand, offset the shrinkage, reduce the absorption, and increase the plasticity of the mortar as measured by flow, without impairing its strength. The metallic content of the non-shrink aggregate shall be pure and shall contain not more than .02% oil and shall not contain any non-ferrous metal particles. Total shrinkage of the mortar shall be less than .001 inches per inch of height at the end of 24 hours. At the end of 28 days, there shall be no shrinkage and the expansion shall be less than 0.5%. Cement and sand will be furnished by the Government.

(b) Payment. - The cost of all labor, plant and materials (except those furnished by the Government) for placing all non-shrink grout, as specified or directed, shall be included in the contract unit price per cubic foot for "Special Non-shrink Grout" "See also paragraph 9-06.)

5-21. WATERPROOFING.

(a) General. - The contractor shall furnish and install all membrane waterproofing, including all metal work, caulking, and associated work shown on detail drawings to be furnished later or directed by the contracting officer.

(b) Materials.

(1) Tarred Felt. Tarred felt for waterproof membrane shall conform to Federal Specification HH-F-201 for "Felt; Coal-Tar-Saturated (for) Roofing and Waterproofing."

(2) Pitch. Pitch shall conform to Federal Specification R-P-381 for "Pitch; Coal-Tar (for) Mineral Surfaced Built-up Roofing, Waterproofing and Dampproofing," Type II.

(3) Copper. All copper sheets shall conform to the requirements of paragraph 6-09, and shall weigh not less than 16 ounces per square foot.

(4) Sheet Lead. All lead shall conform to the requirements of paragraph 6-12, and shall weigh not less than four pounds per square foot.

(5) Miscellaneous Materials. All miscellaneous materials that will be used in connection with this work shall be of the best commercial grades and shall be subject to the approval of the contracting officer.

(c) Metal Work. - The contractor shall furnish and install all copper flashing, counter flashing strips over construction joints and similar work associated with the membrane waterproofing. Flashing shall be installed and sealed into the reglets.

Where reinforcing bars will be run through the waterproof membrane, the steel shall pass through a lead sleeve at least 8 inches high with an 8 inch dimeter flange mopped into the felt. The space between the steel and the lead sleeve shall be filled solid with elastic roofing cement.

(d) Membrane Waterproofing. - Five-ply (or equivalent , of 15 lb. felt) waterproof membrane shall be provided where directed. All surfaces upon which the waterproofing is to be applied shall be dry and free from loose materials and shall be covered by a membrane of continuous waterproofing consisting of five plies of tarred felt and six moppings of pitch.

A coat of hot pitch shall be applied to the surface, and while still hot, a layer of felt and the copper flashings shall be embedded into it, to be followed by alternate moppings of pitch and layers of felt until all layers are in place. Each layer of felt shall be thoroughly rubbed into the hot pitch to insure thorough embedment. The felt shall be laid without wrinkles or buckles and the finished membrane shall be free from pockets or blisters. Felt shall be lapped at ends and edges not less than 10 inches, thoroughly mopping between. Flanges of lead sleeves shall be mopped in below the top layer of felt.

Flashing strips or other sealing means around all other openings through the membrane (such as drains, ventilators, ducts etc.) will be provided and set as described in other sections of these specifications and they shall be mopped in place in a similar manner.

Not less than 140 pounds of pitch shall be used for constructing each 100 square feet of membrane and the pitch shall not be heated above 350 degrees Fahrenheit. At angles, construction joints and places where the waterproofing may be subjected to unusual strain, there shall be applied not less than two extra reinforcing layers of felt and alternate moppings of pitch.

Care shall be taken not to injure the waterproofing membrane either during construction or after application, and all finished work shall be approved before being covered with concrete or other material.

(e) Measurement and Payment for Waterproofing. -

(1) Measurement for payment for membrane waterproofing shall be based on the net areas with no deductions for openings less than 15 square feet in area. Vertical heights from the deck to the reglet shall not be added to the net area of membrane waterproofing.

(2) The cost of all labor, plant, and materials required to furnish and install all waterproofing as specified or directed, shall be included in the contract prices for:

a. "Membrane Waterproofing" per square (100 square feet).

b. "Copper Metal Work," per pound. (See also paragraph 12-09).

c. "Lead Sleeves and Flanges," per pound.

5-22. DAMAGED AND DEFECTIVE CONCRETE. - Concrete containing voids, holes, honeycombing, or similar depression defects shall be completely removed and replaced as specified in paragraph 5-11(a), provided that shallow defects may be repaired with gunite or with an approved compressed air mortar-gun as hereinafter specified when so directed by the contracting officer. In no case will extensive patching of honeycombed concrete be permitted.

Defective surfaces to be repaired with a cement or mortar gun shall be cut back a minimum of one-half inch over the entire area. Feather edges shall be avoided and the thickness at the edge of the patch shall be increased sufficiently to allow the cutting of a key into the solid concrete. When chipping or cutting tools are not required in order to deepen the area properly, the surface shall be prepared for bonding by the removal of all laitance and all soft material, and not less than 1/32" depth of the surface cut from all hard portions by means of an efficient sand blast. After cutting and sandblasting the surfaces shall be wet down sufficiently in advance of shooting so that while the gunite is being applies the surface under repair will remain moist, but not so wet as to overcome the suction upon which a good bond depends. Gunite and mortar for repair purposes shall consist of cement and sand, graded, proportioned, and mixed as directed.

The removal and replacement, or the repair where directed, of any concrete shall be performed at no expense to the Government. The contractor shall be charged for the materials used in such replaced concrete or repair work, the amount that the materials cost the Government at the point of delivery to the contractor.

5-23. MEASUREMENT AND PAYMENT FOR CONCRETE.

(a) Concrete, General. - Measurement of concrete will be made on the basis of the actual volume of concrete within the neat lines of the structures as indicated on the drawings or otherwise required. Measurement of concrete placed against the sides of the excavation without the use of intervening forms will be made only within the neat lines of the structure. No deductions will be made for rounded or beveled edges or space occupied by metal work, electrical conduits, timber, nor for voids which are either less than five (5) cubic feet in volume or one(1) square foot in cross section. Unless otherwise specified, payment for concrete will be made at the applicable contract unit price per cubic yard for "Concrete; Class A, "Con-

crete Class B" or Concrete; Class C" which prices shall include the use of all equipment, tools, material, false-work, bracing, bolts, rods, metal ties, preformed expansion joint filler, asphalt filler, built-up joint filler, canvas, mortar, labor, special provisions for hot and cold weather placing and curing, and all other items required to complete the concrete work.

(b) Additional Concrete. - Any other concrete to be placed and not specifically covered above will be paid for at the that contract unit price for the concrete specified above which is most applicable to the additional concrete placed as determined by the contracting officer. The decision of the contracting officer regarding the classification of such additional concrete will be final. No payment will be made for any additional concrete which may be authorized by the contracting officer at the request of and primarily for the benefit of the contractor, which is not found necessary and required and directed by the contracting officer under the provisions of these specifications.

SECTION VI - MATERIALS

6-01. GENERAL

(a) Materials.- All materials shall be of new unused stock, free from defects. Substitution of size of sections and materials from that shown on the drawings or required in the specifications shall not be made except on written approval of the contracting officer and provided that the cost to the Government shall not be increased thereby.

Materials indicated on the drawings or required in the work and not covered elsewhere in these specifications by detailed requirements, shall conform to the requirements of this section.

The detailed specifications herein may contain materials not required in the completed work. Any materials required which are not covered by detailed specifications herein or elsewhere in the specifications shall conform to the applicable Federal Specifications, grade and/or class as required or, in case where there are no applicable Federal Specifications, to applicable specifications of the American Society for Testing Materials (A.S.T.M.). In all other cases not specifically covered in these specifications, the contractor shall furnish the highest grade commercial material or product.

(b) Inspection, Acceptance and Rejection of Materials.- All materials shall be subject at all times to inspection by the contracting officer who will select such samples in such quantities as he may deem necessary and subject the same to such tests as may be necessary to determine their qualities as herein specified, and he will accept or reject materials in accordance with the results of such tests. Tests may be repeated upon arrival of the various shipments at the site of the work as may be necessary to insure the acceptance of only such materials as will comply with the provisions of the plans and specifications.

(c) Test Specimens. - Special test specimens shall be furnished by the contractor on request; and shall be of such shape and number as designated; and shall in general conform to Federal Specifications or the specifications of the American Society for Testing Materials as to shape, size, and method of testing.

(d) Mill Test Reports.- Mill test reports certified to by qualified technicians shall be furnished when required for all material entering into this work and will, in general, be the basis of acceptance or rejection of the materials. The contracting officer may, however, require of the contractor special chemical or physical test on any part of the material if in his opinion the conditions justify such a check.

6-02. FEDERAL SPECIFICATIONS. - Copies of Federal Specifications referred to herein may be procured from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a price of five or ten cents each. When the term, "Federal Specifications" or "A.S.T.M. Specifications" is cited, the reference shall be construed to mean the specifications as modified by any amendments promulgated before the date of opening bids for the contract. The number and designation of the Federal Specifications or A.S.T.M. Specifications for various materials to be furnished under this contract are as herein after enumerated.

6-03. STRUCTURAL STEEL.

(a) Steel for Structural Uses. - All structural steel required for

the building frame, crane runways, etc., unless for temporary use or to support or retain machinery and other embedded metal parts in alignment until they are concreted in, and unless otherwise specified or indicated, shall be in accordance with Federal Specification QQ-S-711a entitled "Steel, Structural; (for) Bridges," Class A, Structural Steel, and Class C, Rivet Steel, except that the chemical properties shall be so controlled as to permit the material to be easily welded by the arc-welding process where such procedure is to be followed.

(b) Steel for Miscellaneous Uses. - Structural steel for work included under the classifications "Miscellaneous Steel and Iron Work" shall be in accordance with Federal Specification QQ-S-721a entitled "Steel; Structural; (for) Buildings; " Class A, Structural Steel, and Class C, Rivet Steel.

6-04. CONCRETE REINFORCING STEEL.

(a) Reinforcing steel shall conform to Federal Specification QQ-B-71a, for "Bars; Reinforcement, (for) Concrete," Type B, Grade 2, Intermediate Billet Steel or Grade 3, Intermediate Car Axle Steel. Bars 1-1/4 inch square and smaller shall be deformed. The steel shall be properly marked as to grade.

(b) Fabric reinforcement for concrete shall be woven or electrically welded wire fabric of the type, weight and size shown on the drawings. The wire for fabric and for concrete pile reinforcing shall conform to A.S.T.M. Specification A82-34 for "Cold Drawn Steel Wire for Concrete Reinforcement."

6-05. SHEET METAL. - Sheet metal shall conform to Federal Specification QQ-I-696 for "Iron and Steel; Sheet, Black and Zinc Coated (Galvanized)" of the type and class as specified or required. When so specified, sheet shall also conform to definite chemical requirements.

6-06. CORRUGATED IRON PIPE. - Pipe shall conform to Federal specifications QQ-C-806, Type 1, except zinc-coating shall be eliminated. The interior surface shall be cleaned, primed, and lined with coal-tar enamel, and the exterior shall be cleaned, primed, and coated with coal-tar enamel, Type A, with a banded asbestos felt wrapper. All such materials and application shall be in accordance with the requirements of the American Water Works Association Specification 7A.6.

6-07. STEEL RAIL AND FITTINGS. - Steel rail and fittings shall be open hearth steel rolled from new billets and shall conform to the latest standard specifications of the American Railway Engineering Association. Rails shall be A.R.E.A. section, of the weight per yard as specified or required, except that rails for gantry cranes shall be 100 pound A.S.C.E. section, and for overhead cranes they shall be Lorain Section #418, - 175 pounds.

6-08. IRON CASTINGS.

(a) Cast Iron. - Cast iron, unless otherwise specified, shall conform to Federal Specification QQ-I-652 for "Iron, Gray; Castings," of class as required.

(b) Cast Malleable Iron. - Cast malleable iron shall conform to Federal Specification QQ-I-666 and Amendment 1, dated November, 1934, for "Iron , Malleable; Castings," Black (Ungalvanized) Type A, and Zinc Coated

(Galvanized) Type B.

6-09. COPPER.

(a) Plate and Sheets. - Copper plate and sheets shall conform to Federal Specification QQ-C-501 and Amendment 1, dated November, 1936, for "Copper; Bars, Plates, Rods, Shapes, Sheets, and Strips."

(b) Piping. - Copper piping shall conform in all respects to Federal Specification WW-T-799 and Errata - 2, dated April, 1934, for "Tubing; Copper, Seamless (For use with Soldered or Flared-Fittings)," Type K or L as specified or required. Fittings for copper piping shall be die cast brass or copper fittings with capillary channel and feed holes for solder for sweating in place and shall bear the name of the manufacturer stamped thereon.

6-10. BRASS.

(a) Pipe. - Pipe shall conform to Federal Specification WW-P-351 and Errata 1 dated October, 1930, for "Pipe; Brass, Seamless, Iron-Pipe-Size, Standard and Extra-Strong," Grade A.

(b) Pipe Fittings. - Pipe fittings shall conform to Federal Specification WW-P-448 for "Pipe-fittings; Brass or Bronze (Threaded), 125-pound, or to Federal Specification WW-P-461 for "Pipe-Fittings; Bronze (Threaded), 250-pound" as specified or required, composition A or B. Brass unions shall conform to Federal Specification WW-U-516 for "Unions; Brass or Bronze, 250-pound," composition A or B.

6-11. SOLDER.

(a) Solder for Fittings. - Solder for use with fittings for copper tubing shall be a special solder recommended by the manufacturer of the pipe or fittings. Flux shall be non-corrosive.

(b) Solder for Brazing. - Solder for Brazing shall conform to Federal Specification QQ-S-551 for "Solder; Brazing," of composition as specified or other wise directed.

6-12. LEAD. - Lead shall conform to Federal Specification QQ-L-171 for "Lead; Pig," Grade A or QQ-L-201 for "Lead; Sheet," Grade A.

6-13. PREFORMED JOINT FILLER. - Preformed joint filler shall be cork conforming to Federal Specification HH-F-341 for "Filler, Expansion-Joint, Preformed; Non-Extruding and Resilient-Types (for Concrete)." Type II, self-expanding cork, or bituminous fiber expansion joint filler of American Association of State Highway Officials Standard Specification M-59-38.

6-14. SPECIAL BITUMINOUS CEMENT.

(a) Type "B". -Type "B" shall be an internal set-up cement of asphaltic base, composed of a liquid asphaltic fluxing agent with an admixture of powdered asphalt, asbestos fiber and other suitable inorganic fillers. When mixed in the proper proportions, the cement shall be suitable for proper trowel application, and shall harden to a consistency as specified in subparagraph (3) below:

(1) The material shall be supplied in containers of proper relative size to apportion batches with the desired troweling consistency. The liquid asphaltic fluxing agent shall be a smooth uniform mixture, not

thickened or livered, and showing no separation which cannot be easily overcome by stirring. The powdered cement shall be a uniform mix containing no matted lumps of fibre.

(2) When mixed in the proportions recommended by the manufacturer, the cement shall yield no less than 85 percent of non-volatile matter when 10 grams are heated in an oven at 105 to 110 degrees Centigrade for 24 hours.

(3) When tested in accordance with A.S.T.M. Specification D-5-25 for "Penetration of Bituminous materials," the above mixture shall have the following characteristics: Immediately after mixing, using a 5/8 inch diameter steel ball, 114 grams, 5 seconds, the mixture shall permit a penetration greater than 300. The same specimen, after a lapse of 24 hours at 25 degrees C. under water, shall permit a needle penetration, 100 grams, 5 seconds, of not more than 100. The same specimen after a lapse of 30 days at 25 degrees C. under water shall permit a needle penetration, 100 grams, 5 seconds, of not more than 50.

(b) Type "C". - Type "C" cement shall be an internal set-up cement as specified for Type "B", except that it shall have a melting point of between 50 and 55 degrees C., and shall have a needle penetration at 25 degrees C., of not less than 80.

(c) Emulsified Asphalt Joint Filler. - Emulsified asphalt joint filler shall be an emulsified asphalt compound similar and equal to "Static Asphalt, Fibrated," manufactured by the Flintkote Company, 30 Rockefeller Plaza, New York, N. Y.

6-15. STEEL PIPE AND FITTINGS.

(a) Welded or Seamless steel Pipe, Black or Galvanized. - Welded or seamless steel pipe, black or galvanized, class and coating specified or required, shall be of standard commerical grade and sizes in conformity with Federal Specification WW-P-403a for "Pipe; Steel and Ferrous Alloy, Wrought, Iron-Pipe Size," except that test will not be required. Open ends shall be reamed. The pipe shall be straight, clean, and free from scale, rust, oil or other foreign matter. When listed on bills of material, random lengths may be furnished. Electric-fusion-welded steel pipe shall conform to the Specifications of the American Society of Testing Materials for electric-fusion-welded steel pipe (sizes 30 inches and over), Serial Designation A 134-39, or electric-fusion-welded steel pipe (sizes 8 inches to but not including 30 inches), serial designation A 139-39, except that hydrostatic tests will not be required. The wall thickness shall not be less than 1/4 inches.

(b) Screwed Fittings. - Screwed fittings shall be of standard weight, malleable iron, conforming to Federal Specification WW-P-521a for "Pipe-fitting; Malleable-Iron (Threaded), 150 pounds," plain screwed type, plain or galvanized as specified, except that where 300 pound fittings are specified they shall be of the grade commercially known as "300 Pound Malleable Iron Fittings." All fittings shall be of the same weight or grade as the pipe with which they are used.

(c) Unions. - Malleable iron unions shall conform to Federal Specification WW-U-531 for " Unions, Malleable Iron or Steel, 250 Pound," black or zinc-coated as specified; except that where specified as 300 pound, they shall be of the commercial grade known as "300 pound Malleable Iron Unions."

(d) Forged Steel Flanges and Flanged Fittings. - Forged steel flanges and flanged fittings shall be made of carbon steel and shall be

300 pound class.

6-16. WROUGHT IRON PIPE AND FITTINGS. - Wrought iron pipe shall conform to Federal Specification WW-P-441a for "Pipe; Wrought-Iron, Welded, Black and Zinc-Coated," Class A, standard or Class B, extra strong. Open ends shall be reamed. The requirements in the specifications for fittings for steel pipe shall apply also to fittings for wrought iron pipe. Where so specified herein after, wrought iron pipe shall be pickled at the mill to remove scale. Welding fittings shall be genuine wrought iron of long radius type, fabricated from tubing which satisfies the requirements for wrought iron pipe as specified herein, and shall be pickled.

6-17. CAST IRON PIPE AND FITTINGS.

(a) Cast iron pipe and fittings for sanitary lines shall conform to Federal Specification WW-P-401 for "Pipe and Pipe Fittings; Soil, Cast Iron."

(b) Cast iron pipe and fittings for water lines shall conform to Federal Specification WW-P-421 for "Pipe; Water, Cast Iron (Bell and Spigot," Class 150.

(c) Acid proof pipe and fittings shall be similar and at least equal to "Duriron" pipe and fittings.

(d) Cast iron drain fittings shall conform to Federal Specification WW-P-491 for "Pipe-Fittings; Cast Iron, Drainage," of types and sizes shown on the drawings or directed.

(e) Cast iron flanges and flanged fittings shall be of the grade commonly known as "125 Pound Cast Iron," faced and drilled.

6-18. STANDARD BOLTS. - Bolts shall conform to Federal Specification FF-B-571a and Amendment 1, dated April 1935, for "Bolts; Nuts; Studs; and Tap-Rivets (and material for same)." Unless otherwise specified or required, bolts shall be of type "B-2" and nuts of Class "C" steel, Type "A-2," with Class 3 medium fit. Zinc or cadmium coated bolts shall be furnished where specified, indicated or required.

6-19. LOCK WASHERS. - Lock washers shall be of the "Kantlink" type and shall conform to the S.A.E. standard dimensions and requirements, for lock washers of regular section. Material shall be either S.A.E. XI055 or S.A.E. 1060.

6-20. STEEL WIRE ROPE. - Steel wire rope shall conform to Federal Specifications RR-R-571 and Amendment 3, dated August 1939, for "Rope Wire" of sizes and types as specified or otherwise required.

6-21. FLOOR PLATING. - Floor plating indicated on the drawings shall be of carbon steel of the thickness specified or required, with a raised pattern on one side which will provide a non-skid surface in any direction. The reverse side of the plates shall be smooth. The specified thickness of the plate shall be exclusive of the raised pattern, which shall project not less than 5/64-inch and shall have a top free from sharp corners. They shall be closely spaced so that the foot will always be in contact with several of the raised portions.

6-22. PRESSURE LUBRICANTS. - Grease for pressure lubrication, except that for gate wheel bearings, shall conform to Federal Specification VV-G-681

for "Grease; Lubricating, Mineral," medium grade. Pressure lubricant for gate wheel bearings shall be that recommended by the bearing manufacturer and shall be effective at-40 degrees F.

6-23. MEASUREMENT AND PAYMENT.

(a) Unit Weights. - Unit weights for metal work classified and paid for by weight shall be as follows:

Nickel steel	.285 lbs. per cu. in.
Chrome nickel steel	.285 " " " "
Iron castings	.260 " " " "
Bronze, brass and copper	.311 " " " "
Babbitt metal	.270 " " " "
Lead	.409 " " " "
All other metals	.283 " " " "

All other materials for which payment is not specifically provided elsewhere will be paid for on the basis of the respective unit measures, as listed in the schedules at the contract unit prices.

(b) Bills of Material. - The contractor shall submit to the contracting officer calculated bills of material in quadruplicate, showing in detail the material actually incorporated in the finished apparatus. These bills of material shall be prepared from the final shop drawings, and shall be figured according to the procedure described above.

(c) Partial Payment. Unless otherwise specified, estimates will be given for 60 percent of the contract prices for all metal work delivered and accepted at the site of the work, for which payment is on a pound price basis, provided such material be stored and protected from deterioration in a manner satisfactory to the contracting officer. The remaining 40 percent will be estimated when the material is incorporated in the work and accepted. If any material so stored and partly paid for, be not kept protected in a manner satisfactory to the contracting officer, no further partial payments on metal work as provided for in this paragraph will be made and the material will be kept protected by the contracting officer at the expense of the contractor.

SECTION VII - STRUCTURAL STEEL AND MISCELLANEOUS STEEL AND METAL WORK

7-01. GENERAL

(a) Work Included. - The contractor shall furnish, fabricate, and erect structural steel building frames and all other structural steel work not specifically included elsewhere in these specifications, and all miscellaneous steel and metal work incidental to the work to be performed as shown on the drawings or as directed by the contracting officer. The work shall include all anchor bolts, expansion bolts, and other forms of anchorage indicated or required for placing or attaching of the steel and metal work to supporting or adjoining structures. The work shall include all labor and material required for furnishing, unloading, transporting, storing, erecting, and required painting of the following items:

(1) Structural Steel. - In general the structural steel work to be furnished under this heading is steel building frames, crane runway beams, rails and fittings, trestles, and girders.

(2) Miscellaneous Steel and Metal Work. - The items that are included under this heading are listed in paragraph 7-09.

(b) Temporary Construction Use. - With the approval of the contracting officer, the contractor will be permitted to temporarily use any available work of the permanent structural steel work for any purpose for which it may be suitable. All steel work so used shall be properly maintained, shall not be overstressed, and shall be restored to its original condition after such temporary use. In case of irreparable damage to any such material, it shall be replaced at the contractor's expense.

7-02. GENERAL SPECIFICATIONS FOR METALS.

(a) Requirements. - The requirements for all classes of metals are included in Section VI of these specifications.

(b) Tests and Trials.

(1) The contractor shall make analyses and/ or tests to determine that all materials are in conformity with the specifications except where tests are waived or not required by the contracting officer. Such analyses and/ or tests, except where waived or modified, shall be made as indicated in the respective detailed specifications or as otherwise required.

(2) When doubt exists as to the soundness of any part, such part may be subjected to X-ray or Gamma-ray inspection at the discretion of the contracting officer and the cost of such inspection will be borne by the United States.

(3) Any defects disclosed by tests and trials shall be immediately remedied by the contractor, without expense to the United States, and a satisfactory test completed.

7-03. LIST OF MATERIALS. - The contractor shall furnish the contracting officer copies of all purchase orders, mill orders and shop orders for material, and work orders. The contractor shall also furnish a shipping bill or memorandum of each shipment of finished pieces or members giving the designation mark and weight of each piece, the number of pieces, the total weight, and if shipped by rail the car initial and number.

Copies of certificates of tests and shipping bills in triplicate and all orders in quadruplicate shall be mailed promptly to the United States Engineer Office, Massena, New York.

7-04. PATTERNS. - A complete set of patterns in first class condition for all castings detailed on the drawings or which are not the standard stock product of a commercial manufacturer shall be furnished by the contractor and shall become the property of the United States, and shall not be used for work under any other contract unless specifically authorized or directed by the contracting officer. Dimensions of castings shown on drawings are finished dimensions.

7-05. PART IDENTIFICATION AND WEIGHT REQUIREMENTS. - Each casting and each shop fabricated shipping piece shall be properly identified and legibly marked in conformity with the erection drawings. Parts weighing more than one ton shall have the weight plainly marked thereon. Parts requiring selective assembly in the field shall be match-marked after shop assembly.

7-06. SHOP INSPECTION. - The contractor shall keep the contracting officer informed as to commencement and progress of the work. In accordance with Article 6 of the contract, the contractor shall at all times permit Government inspectors free access to all parts of mills, foundries or shops where work is being carried on under the contract and shall provide the necessary facilities and assistance for making thorough examinations. Unless waived in writing by the contracting officer, mill inspection will be required on all metals. The acceptance of any material or finished member by an inspector shall not prevent subsequent rejection of such material or member is later found to be defective.

7-07. METAL WORK FABRICATION AND ASSEMBLY.

(a) General. - Except as otherwise noted in these specifications, fabrication of structural steel shall be in accordance with Section 25 of the "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" as adopted by the American Institute of Steel Construction, and revised in 1937. Erection of structural steel shall be in accordance with Section 27 of the above-mentioned specification except that paragraph (g) shall be inoperative and the requirements of paragraph (f) shall not apply to previously shop assembled and match-marked units.

(b) Holes. - For work requiring unusual accuracy in fabrication or erection, as governed by tolerances, holes shall be sub-punched and reamed after assembly in material 3/4 inch or less in thickness but in material over 3/4 inch in thickness shall be drilled full size after assembly or drilled at least 1/8 inch less than the nominal rivet or bolt diameter before assembly and reamed full-size after assembly. Holes for turned bolts in this class of work shall have a Class 4 fit with the finished shanks of the bolts as defined by Bulletin B4a-1925 of the American Standards Association. For sub-punching, the diameter of the punch shall be 3/16 inch smaller than the nominal diameter of the rivet. For punching full-size, the diameter of the punch shall be 1/16 inch larger than the diameter of the rivet. In each case, the diameter of the die shall be not more than 3/32 inch larger than the diameter of the punch.

(c) Bolts and Nuts.

(1) Special bolts shall conform to Federal Specification FF-B-571a, for "Bolts; Nuts; Studs; and Tap Rivets (and Material for Same),

coarse thread series, with dimensions and fits as specified below for the respective applications. Bolt diameters specified are those for standard nuts; where special wrenches are required at least two wrenches of each size shall be furnished.

(2) Bolts for Machinery Connections. - Bolts and nuts for electrical machinery shall have Class 2 free fit. Where operating machinery connections are made with spot faced and reamed holes, turned bolts shall be supplied, finished all over, with type "B-3" heads and type "A-3" nuts with Class 3 medium fit. The body diameter shall be 1/16 inch larger than the threaded portion, and the unthreaded portion shall be 1/16 inch to 1/8 inch shorter than the thickness of the connected members. The bolts shall be fitted into holes reamed to provide 0.010 inch maximum clearance.

(3) Turned bolts for structural connections shall be finished all over, with type "B-3" heads and type "A-3" nuts. The body diameter shall be 1/16 inch larger than the nominal size for a rivet connection and at least 1/16 inch larger than the diameter of the threaded portion. The unthreaded portion shall be 1/16 inch to 1/8 inch longer than the thickness of the connected members. Bolt holes shall be reamed normal to the member during assembly to provide a drive fit for the bolts.

(4) Washers of not less than 1/8 inch thickness shall be used under all nuts except where holes are spot faced and unless otherwise specified, or required. Cut washers shall be of structural steel and ogee washers of cast iron

(d) Welding.

(1) General.

a. Unless otherwise authorized, and except for temporary supports and the work specified as miscellaneous steel and metal work in paragraph 7-09, all welding shall be done by the electric arc method, using a process which shall exclude the atmosphere from the molten metal, and shall conform to the provisions of the current specifications of the American Welding Society applicable to the work to be done, as determined by the contracting officer, and as further specified below. Welding operators shall be qualified, at the expense of the contractor, as required by the specifications of either the American Welding Society, the U. S. Navy Department Bureau of Construction and Repair, or the U. S. Bureau of Navigation and Steamboat Inspection, and the contractor shall certify by name to the contracting officer the welding operators so qualified, and the code under which qualified. In no case shall welding be done when the temperature of the metal is below 10 degrees F. or when inclement weather or physical conditions are such as may, in the opinion of the contracting officer, be unsuitable and impair the efficiency of the welder in making acceptable welds, unless approved steps are taken to correct such conditions.

b. Inspection. - The inspectors shall have the right to cut coupons from any location in any joint for testing. Should any two coupons cut from the work of any welder show strengths under test less than that of the base metal, it will be considered evidence of negligence or incompetence and such welder shall be permanently removed from the work.

(2) Filler Metal.

a. Unless otherwise specified or authorized, all deposited weld metal shall have elastic limits and ultimate tensile strengths not less than those of the respective metals; elongation within 5 percent of that of the base metal; and chemical composition similar to that of the

base metal. These properties shall be determined by testing in accordance with the applicable provisions of the current specifications of the American Welding Society.

(b). Welding electrodes and rods shall be of type and grade as approved by the contracting officer and of such chemical composition and physical properties as will produce the characteristics specified above and so adapted to the base metal and thickness of parts to be welded as will insure effective penetration and an intimate uniform fusion of the filler and base metals. The electrodes and coating shall conform in dimensions and physical characteristics to applicable provisions of the current specifications of the American Welding Society. In welding stainless steel, columbium-bearing welding rods shall be used.

(3) Special Workmanship Requirements.

a. Welding Procedure. - The contractor shall prepare his own schedule of welding procedure for each structure to be welded, and shall submit the procedure to the contracting officer for approval. The procedure shall be in accordance with best modern standard welding practice, as approved by the contracting officer, and shall be such as to minimize locked-up stresses and distortion of the finished members of the structure. No welding shall be done on any structure until the procedure for that structure has been approved. Approval of any procedure, however, will not relieve the contractor of sole responsibilty for its adequacy for producing a finished structure meeting all requirements of these specifications.

b. Welds. - A wandering or skip sequence of welding shall be used on all passes of welded joints. The maximum length of bead, laid in any one continuous or skip pass shall be that which can be laid with one electrode. Welds shall be of type, size and dimensions approved by the contracting officer. Welds 3/8 inch and larger shall be made in not less than two passes; and successive beads or layers shall be uniform in thickness. No electrodes larger than 1/4 inch in nominal diameter shall be used unless authorized by the contracting officer. In all welding, the application of the first pass shall be given special attention to insure satisfactory penetration and fusion of the filler and base metals. Wherever there is danger of the assembled structure or member becoming warped or distorted by localized welding stresses, the welds shall be effectively stress relieved.

c. Assembling Devices and Temporary Connections. - Preparatory for welding, the assembled elements of member shall be held rigidly in position by the use of approved devices adapted to the purpose, and capable of exerting pressures requisite to remove local distortions and compress the parts into intimate contact except where root openings are required. Bolts may be used for temporary connections provided that the bolt holes are subsequently filled with sound weld metal in an approved manner and ground flush with adjacent base metal, unless otherwise authorized. Welding for temporary connections and bracing will be permitted povided that, where such welded connection does not form a part of a later permanent connection, such weld metal shall be removed approximately flush with adjacent base metal where so directed.

(4) Flame cutting shall conform to the applicable provisions of the current specifications of the American Welding Society. Metal cutting shall not be done with electric arc.

(e) Metallic Coatings. - Zinc coatings shall be applied in a manner and of a thickness and quality conforming to A.S.T.M. Specification A 123-33 for "Zinc (hot galvanized) Coatings on Structural Steel Shapes,

Plates, Bars and their Products." Sherardizing and Cadmium plating shall have thickness and durability equal to or greater than Zinc Coating applied as specified above.

(f) Machining.

(1) General. - All tolerances, allowances and gages for metal fits shall conform to standards as approved by the American Standards Association, December 1925. Machine work shall be done wherever an "f" or any work denoting machine finish appears on the drawings and at other places where necessary. Where the "f" follows a dimension, both surfaces from which it is measured shall be machine finished so that they will be true to the dimensions shown. All finished contact or bearing surfaces shall be true and exact to secure full and complete contact. All drilled holes for bolts shall be accurately located and drilled from templates.

(2) Pin holes shall be bored true to gages, smooth and straight and at right angles to the axis of the member. The boring shall be done after the member is securely fastened in position by bolts or rivets as specified or otherwise required.

(3) protection of Machined Surfaces. - All machine finished surfaces and threads shall be thoroughly cleaned of foreign matter and coated with a composition of white lead and tallow or other approved slushing grease for protection against rust.

(g) Unfinished Surfaces. - So far as practicable, all work shall be laid out to secure proper matching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surfaces, they shall be chipped or machined to secure proper alignment. Unfinished surfaces shall be true to the lines and dimensions shown on the drawings and shall be chipped or ground free of all projections and rough spots. Depressions or holes not affecting the strength or usefulness of the parts, with the approval of the inspector, may be welded.

7-08. ERECTION.

(a) General. - All bases for structural steel shall be set and wedged to the lines and grades established by the contracting officer. Columns and frames shall be plumbed and accurately aligned and connections shall be accurately and securely fitted up before riveting. Rivets driven in the field shall be heated and driven with the same care as though driven in the shop, and holes for turned bolts to be inserted in the field shall be reamed in the field, both in accordance with the standard specifications referred to in paragraph 7-07 (a). All necessary fitting, field riveting, welding, brazing and placing of castings, bearing plates, sole plates, bolsters, shoes, anchor bolts, turned bolts, and other required fittings shall be included in the work.

(b) Embedded Items. - Provision shall be made for the placement of all embedded metal work before concrete is placed or, if shown on the drawings or directed, the contractor shall provide recesses or block-outs in the concrete, in which case the metal work to be embedded shall be installed and grouted in place after concrete has been placed. Anchor bolts shall be installed when the concrete is placed, unless otherwise shown or directed. Metal work to be embedded in concrete shall be accurately placed and shall be held in correct position and alignment while the concrete is being placed. Where it is impracticable to place anchors or anchor bolts required for the installation of comparatively light metal accessories before the concrete is placed, holes shall be drilled by the contractor in the concrete, and lead

expansion anchors shall be installed as directed. Erection of structural steel to be embedded in concrete shall include removal of shop paint and cleaning in accordance with Section XIII.

(c) Crane and Railroad Track Rails. - All rails for intake and draft tube gate gantries and overhead cranes and for the railroad track in the powerhouse shall be installed as shown on the drawings. Joints in rails shall be made with standard splice bar connections allowing the proper space for expansion depending upon the exposure condition. Rails shall be carefully and accurately aligned throughout their entire length and shimmed to exact grade, then permanently secured in place by bolts and grout or with clips.

7-09. MISCELLANEOUS STEEL AND METAL WORK.

(a) General. - The contractor shall furnish and install all items of miscellaneous steel and metal work as shown on the drawings, necessary to complete the work, or directed by the contracting officer. Unless otherwise specified, all material shall be in accordance with Section VI.

These items of miscellaneous steel and metal work include, but are not limited to, the following: steel door and other frames, loose lintels, stair treads, steel or cast iron thresholds, ladder rungs, gratings, checker, plates, manhole covers and frames, curb and corner protection angles, eyebolts, and all anchor bolts or anchors for the aforesaid items, or as required in the construction of the work; excepting only anchor bolts to be furnished for and with structural steel and the anchor bolts specified as part of the work covered in other sections of these specifications.

Where specified or where used on the exterior or in locations subject to more or less continual dampness all parts such as ladder rungs, gratings and checker plate shall be hot galvanized after fabrication, if so directed.

(b) Door Frames. - Door frames built of structural steel shapes are included in this section. The steel door frames and rough door bucks shall be provided with clip angles for bolting to the floor and steel strap anchors for embedment in concrete or tile walls. Anchors for tile walls shall be adjustable for height. Corners shall be mitered and welded. Temporary bracing shall be used to prevent the frames from becoming sprung during shipping and erection.

(c) Miscellaneous Frames. - The contractor shall furnish and install all steel channel and angle frames, corner guards and protection angles necessary to complete the work or as directed by the contracting officer. Frames shall be provided with at least 1/4 by 1-1/2 by 8 inch strap anchors not more than 24 inches on centers.

(d) Lintels. - The contractor shall furnish all "loose" steel lintels over openings.

(e) Cast Iron Thresholds. - The contractor shall furnish cast iron thresholds where indicated on the drawings or as directed by the contracting officer. Thresholds shall be cast to standard dimensions and shapes the full widths of the openings and shall be thoroughly anchored to the concrete. Material and surface finish for thresholds shall conform to the specifications for safety treads (Paragraph (k) below).

(f) Cast Iron Covers. - Covers over drain trenches shall be made of cast iron where so indicated on the drawings or directed by the contracting officer. Castings shall be manufacturer's standard pattern capable of safely supporting a load of 500 pounds per square foot. Covers shall be cast in separate sections to facilitate removal. Cast iron shall be as specified in paragraph 6-08.

(g) Ladder Rungs. - Ladder rungs to be cast in concrete shall be bent from wrought iron bars. They shall be carefully set in place to true alignment and projection from the surface. Wrought iron shall conform to Federal Specification QQ-I-686a, "Iron, Wrought (Refined); Bars" Grade C.

(h) Gratings and Fasteners. - Gratings and fasteners shall conform to Federal Specification RR-G-661a for, "Gratings; Steel, Floor (except for Naval Vessels)," Type I, welded cross members, black or galvanized as specified or directed. Sides and ends of gratings shall be finished with a bar the same size and depth as the main grating bars.

(i) Checkered Plates. - Checkered plates, where indicated on the drawings, shall be standard floor plates as rolled by the mills, with projecting ribs of pattern as selected or approved by the contracting officer.

(j) Manhole Covers and Frames. - The cast iron manhole frames and covers shall be of manufacturer's standard patterns, and of types and sizes required or directed by the contracting officer. Cast iron shall be as specified in paragraph 6-08.

(k) Safety Treads. - Treads on conrete stairs, where shown on drawings as C.I., shall conform in all respects to Federal Specification RR-T-661, for "Treads; Safety, Metallic," Type B and Class 6. Safety treads shall have the minimum thickness of 5/16 inches, a nosing of not less than 1/4 inch and shall be of the lengths and widths shown on the drawings. Safety treads shall have a fluted or grooved walking surface with a slip-preventing and wear-resisting abrasive material embedded in it. Treads shall be set flush with the surface and shall be firmly anchored.

(l) Pipe Handrail. - Pipe handrailing shall be of standard black steel pipe conforming to sub-paragraph 6-15 (a), of dimensions and sizes as indicated on the drawings or as directed by the contracting officer. Fittings shall be malleable iron, ball pattern with screwed joints or slip joints, pin connected, as required. The contract price shall include the attaching flanges and pins.

(m) Anchor Bolts. - Under this subparagraph, the contractor shall furnish and set all anchor bolts (except those specified elsewhere to be furnished for and set with such parts as the structural steel work, turbines governors, etc.), required for completion of the work. Bolts shall be provided with sleeves, washers, nuts and other items as required.

In general, anchor bolts shall be set when the concrete is placed. If necessary, they shall be set with a template but in all cases, they shall be securely wired or otherwise fixed in place so as not to be moved out of correct position during placing of concrete. Where pipe sleeves are used, they shall be stopped with wood plugs or other means to prevent the concrete from filling the pipe. Threads shall be properly protected from damage at all times.

(n) Miscellaneous Items. - All other miscellaneous iron and metal work shown on the drawings or required for the completion of the work shall be fabricated and installed as shown or directed using first-class material and workmanship throughout.

7-10. MEASUREMENT AND PAYMENT. - Unless otherwise specified, measurement for payment for structural steel and for miscellaneous steel and metalwork shall be on the basis of fabricated scale weights, except that no payment shall be made for weight in excess of 4 percent for fabricated shapes, bars and plates, and 5 percent for castings and forgings, of the computed weight as determined from theoretical dimensions shown on the drawings for the individual items. Where it is not practicable, in the opinion of the

contracting officer, to obtain scale weights, payment shall be based on computed weights. In computing weights, no allowance will be made for overweight tolerances or protective coatings. Computed weights used as a basis for payment, or for checking scale weights of structural steel shall be based on a unit weight of 0.283 pounds per cubic inch.

The cost of all labor and material, including anchor bolts, required to furnish and place all structural steel as defined in paragraph 7-01 (a), and as shown on the drawings or as specified and directed, shall be included in the bid prices and made at the contract unit prices per pound for:

1. "Structural Steel."
2. "Steel Track Rails."

The cost of all labor and material required to furnish and place all miscellaneous steel and metal work shall be included in the bid prices and made at the contract unit prices per pound for:

1. "Miscellaneous Black Steel and Metal Work."
2. "Miscellaneous Galvanized Steel and Metal Work."
3. "Plain Gratings."
4. "Galvanized Gratings."
5. "Safety Treads and Thresholds."
6. "Cast Iron Frames and Covers."
7. "Forgings, Steel."
8. "Bronze."
9. "Miscellaneous Non-Ferrous Metals."
10. "Pipe Handrail."

Any metal work not specifically included in a separate class shall be included in either "Miscellaneous Black Steel and Metalwork" or "Miscellaneous Galvanized Steel and Metalwork," as applicable.

Payment for all bolts, nuts, pins, washers, expansion bolts, drift bolts and spikes 3/8 inch in diameter and over, anchor rods made from structural steel or bolt steel, will be made at the contract price for "Forgings; Steel," unless otherwise specifically provided for. Brass will be paid for as "Bronze," and babbitt, lead, zinc and other non-ferrous metals, for which payment is not otherwise provided will be paid for as "Miscellaneous Non-Ferrous Metals."

SECTION VIII - ELECTRICAL WORK

8-01. GENERAL.

(a) The conduit system for the future electrical wiring for light, control, plant power and communication uses shall be located and installed as shown on detailed drawings to be furnished at a later date. Unless otherwise indicated on detail drawings or further specifications, to be furnished later, all outlet boxes shall be of the malleable iron, threaded type, and all such boxes below Elevation 170.0 shall be of a type that will mount watertight fixtures. Furnishing and installing all wires and fixtures will be by others.

(b) All work shall be done and completed in a thorough and workmanlike manner and shall conform to the best modern practice in this class of work, notwithstanding any omissions in the specifications or drawings. All conduit and boxes shall be securely wired or nailed in place so that movement during pouring of concrete is impossible. Ends of metal conduit shall be reamed to remove rough edges and burrs. Joints between lengths of conduits, and at entrances to switches, junction boxes and fittings, shall be watertight and otherwise tightly made to provide electrical continuity of a given conduit system or run. All threaded joints shall be made with red lead or similar substance and shall be screwed up tight to make the connection watertight. No threadless fittings or running-thread couplings shall be used on runs of standard conduit. Any run of conduit extending through a construction joint, or changing from an embedded to an open run, shall extend not less than the threaded length plus 1 inch past the face of the concrete. All conduit bends shall have a radius not less than that of standard factory bends. Field bends may be used if of the proper radius and if carefully made with suitable tools so that the conduit is not flattened. All conduit leaving the concrete shall be aligned at 90 degrees to the concrete surface, except as otherwise shown. Except when working on the run, all conduit terminations shall be threaded and sealed with pipe caps, couplings and pipe plugs or conduit bushings and metal discs to exclude dirt and moisture. Ends shall be sealed before concreting operations are commenced, and all boxes shall be properly protected to prevent entrance of concrete, water, or other materials into conduit runs. Conduit runs shall be pitched to provide adequate drainage.

(c) After the conduit is in place and before the concrete is poured, the contractor shall, in the presence of the contracting officer's representative, draw a mandrel through each run of conduit and, should the mandrel fail to pass through, a new bend or length of conduit shall be installed at the points of obstruction. Metal mandrels, with hemispherical ends, shall conform to the following dimensions:

	Diameter, Inches	Length, Inches
For 3/4" conduit	0.62	1.24
For 1" conduit	0.78	1.57
For 1-1/4" conduit	1.03	2.07
For 1-1/2" conduit	1.20	2.42
For 2" conduit	1.55	3.10
For 2-1/2" conduit	1.85	3.70
For 3" conduit	2.30	4.60

(d) After a system of conduit is in place and before the concrete is poured, the contractor shall obtain a written order from the contracting officer's representative to the effect that all conduit to be covered by the pour is in place and has passed the inspection as set forth above, and that pouring may proceed.

(e) During concrete operations, extreme care shall be exercised to avoid damage to the conduit installation.

(f) As soon as possible after the concrete has set in a given pour, each conduit shall be cleaned and inspected for continuity and freedom from obstructions. The conduit shall be cleaned by means of a steel wire flue brush of suitable dimensions. A mandrel as specified above shall then be passed through the conduit. After removal of forms the contractor shall cap or plug all conduit ends not in boxes and shall leave all boxes covered with temporary blank composition or metal covers fitted with gaskets.

(g) At the completion of the contract an inspection will be made of all boxes and conduit runs. The contractor shall again test each section of conduit with a mandrel, as specified above, in the presence of the contracting officer's representative, and the contractor will be required to remove and replace at his own expense, any section of conduit which will not pass the mandrel unless stopage in the conduit can be cleared by methods which meet the approval of the contracting officer's representative. Each box which is not set true with the surface of the concrete or which is not plumb, shall be removed and replaced with new boxes unless the defective installation can be repaired or adjusted to the satisfaction of the contracting officer's representative.

8-02. MATERIALS

(a) Rigid metal conduit shall conform to Federal Specification WW-C-581a for "Conduit; Steel, Rigid, Zinc-Coated."

(b) Conduit fittings shall be galvanized, sheradized or cadmium plated high test gray iron or malleable iron castings of the types and sizes specified and indicated on the plans. They shall be approved by the National Board of Fire Underwriters. Approved gaskets shall be provided on all condulets.

(c) The materials specified under this section shall be furnished only as required for the respective items of work and equipment shown and/or specified.

8-03. STANDARD RULES AND SPECIFICATIONS. - Unless otherwise specified, all electrical materials, workmanship and tests shall be in conformity with the current standard rules, regulations and specifications of the following authorities:

(a) National Board of Fire Underwriters
(205 East Ohio St., Chicago Ill.)

(b) National Electrical Manufacturers Association
(420 Lexington Avenue, New York, N. Y.)

(c) American Institute of Electrical Engineers
(33 W. 39th Street, New York, N. Y.)

(d) Bureau of Standards, (National Electrical Safety Code),
(Superintendent of Documents, U. S. Goverment

Printing Office, Washington, D. C.)

8-04. MEASUREMENT FOR PAYMENT. - Measurement for payment for conduit, fittings and boxes shall be based on the nominal weight of the material actually installed as shown on the drawings, not including waste, temporary supports, or sections abandoned or replaced at the direction of the contracting officer.

8-05. PAYMENT. - The cost of all plant, labor and material necessary to furnish, install and test the complete system of conduit runs, as specified or directed, shall be included in the contract unit prices per pound for "Conduit and Fittings" and "Outlet Boxes."

SECTION IX

INSTALLATION OF TURBINE EMBEDDED PARTS

9-01. GENERAL. The work under this section includes the installation of all embedded turbine parts and equipment to be furnished to the Government by the turbine manufacturers under separate contracts. The contractor shall install the turbine embedded parts, which, with the supporting jacks, tie-rods, hold-down turnbuckles and piping as hereinafter specified, and all fitting - up bolts and field rivets and bolts, will be furnished by the turbine manufacturers. The contractor shall unload the equipment from the cars and suitably store and protect it until ready to place it in the work.

The equipment will be assembled, inspected for fit, marked and match-marked to facilitate assembly in the field, disassembled as required for shipment, and given a priming coat of paint, before shipment from the factory.

The contractor shall furnish all labor, supplies, bracing and supports not specifically stated herein to be furnished by others, and equipment necessary to install the turbine embedded parts in a workmanlike manner as specified, or directed by the contracting officer. Extreme accuracy will be required in placing the equipment. The contractor shall install the work under the supervision of erecting engineers representing the turbine manufacturers who will be paid by the Government and who will direct the proper erection of the turbine embedded parts.

The work shall be done by the contractor in accordance with the erecting engineers' directions, and the tolerances required in the placing of parts shall be as fixed by them. Temporary bracing, ties, stays and supports required for the embedded parts during concreting shall be furnished and placed by the contractor strictly in accordance with the directions of the erecting engineers.

Contract drawings, specifications, and shop drawings from the turbine manufacturers, together with their estimated weights, are available in the following offices:

District Engineer	Massena, New York
Chief of Engineers	Washington, D. C.

9-02. DELIVERY. The turbine parts and piping to be installed under this contract are to be built, and it is estimated that they will be shipped by the turbine manufacturers, on or about the following dates:

In the event that these parts are not shipped on or before the above dates, and the contractor's schedule of operations is delayed thereby, additional time in which to complete work under this contract will be allowed as specified in paragraph 1-27.

9-03. WEIGHTS. The approximate weights of the turbine parts as stated by the turbine manufacturers are listed below for the information of the contractor, but the Government will not be held liable for any claims or damage due to changes in the weights as finally ascertained:

Item	Main Unit (67,100 HP)	House Unit (9,000 HP)
Heaviest embedded piece to be handled in substructure construction	_____lbs.	_____lbs.
Scroll Case		_____lbs.
Pit Liner	_____lbs.	_____lbs.
Draft Tube Liner	_____lbs.	_____lbs.
Discharge Ring	_____lbs.	_____lbs.
Bottom Plate	_____lbs.	_____lbs.
Speed Ring	_____lbs.	_____lbs.
Embedded Piping	_____lbs.	_____lbs.

9-04. ASSEMBLY AND PLACING.

(a) General. The power plant rate of construction shall be such that the placing of turbine parts shall follow their delivery as closely as practicable.

The supporting jacks, tie-rods with turnbuckles and anchor bolts for setting and aligning the turbine embedded parts, will be furnished by the turbine manufacturers.

The contractor shall furnish all jacking pedestals required for the erection of the equipment. Pedestals shall be of ample strength to support the weight and of proper size for their particular use.

Anchor loops of reinforcing steel to which the tie-rods will be attached shall be furnished and installed by the contractor, and will be paid for as "Reinforcing Steel", as specified in paragraph 5-14(i).

(b) Erection of Steel Plate Work.

(1) General. All erection and field riveting and welding of the scroll cases, pit liners and draft tube liners shall be in accordance with the best modern practice.

(2) Rivets. Rivets for the scroll case and penstock extension for the 9,000 hp turbine shall have button heads on exterior and cone (or steeple) heads on interior of pipe. Other rivets may be cone or button heads. Rivets shall be hot driven with pressure tools and in no case will hand driving be permitted. Rivets 1-½ inch and larger shall be "double-gunned", using either a riveter or an air jam for backing-up purposes. Rivets shall be free from slag and adhesive materials, and shall have heads of approved shape, full size and concentric with shank. When driven, rivets shall completely fill the holes and be neat and finished. Recupping or caulking will not be permitted.

Drifting or oversize reaming to enlarge unfair holes will not be allowed. Loose, burned or otherwise defective rivets shall be cut out, or drilled out if necessary, in the opinion of the contracting office, and replaced. Rivets shall be uniformly heated to a light cherry red heat in an approved oil, gas or electric furnace.

Tolerance for body diameter of rivets shall be within the following limits.

Diameter of Rivet	Plus	Minus
1-¼"	.012"	.024"
1"	.012"	.020"
7/8"	.012"	.020"

(3) Welding. Welding shall conform to the provisions of paragraph 7-07(d).

(o) Placing Concrete and Grout. Holes will be provided in the speed rings to facilitate placing concrete underneath them. Tapped holes are also provided in the speed rings and where required in the upper faces of the discharge rings for the pressure grouting. The contractor shall place the concrete and grout, in accordance with details thereof in Section V, and as directed by the contracting officer. The contractor shall place the cover plates in the concreting holes and weld them shut and he shall place the plugs in the grout holes and grind smooth. Cover plates and plugs for grout holes are to be furnished by the turbine manufacturers.

9-05. PIPING. The turbine manufacturers will furnish and this contractor shall place (a) the water piping from the outlets on the underside of the speed rings to the discharge rings (for lubricationg the lower seal rings), and (b) the drain piping from the underside of the speed rings to the draft tubes (for the eductor drains from the head covers).

All pipe before being encased in concrete shall be tested with compressed air and soap solution, or as directed by the contracting officer, and made tight.

The turbine manufacturers will furnish piezometer connections at the scroll case of the house unit. Piping therefrom shall be installed as part of the work included in Section XI, Piping.

9-06. PAYMENT. The cost of all plant, labor and materials (except those specified to be furnished by the Government) required to assemble and place the embedded turbine parts and piping described in paragraphs 9-01 to 9-05, including unloading, hauling, storing, handling, assembling and installing, as specified or directed, shall be included in the contract price, per ton, for "Turbine Embedded Parts, Installation".

The cost of placing concrete and poured or pressure grout under and around the embedded parts shall be included in the applicable contract price in Section V (for grouting see paragraph 5-18(g), 5-19 and 5-20).

SECTION X - INSTALLATION OF GATES, CRANES AND HOISTS

10-01. REQUIREMENT.

(a) The contractor shall, as required, unload, check, store, install, adjust, paint and test the following items:

4- Main powerhouse cranes of 300 tons capacity each.

3- Overhead traveling cranes in the downstream erection bays, 200 tons capacity each.

2- Draft tube stop log gantry cranes, 10 tons capacity each.

2- Intake-gate gantry cranes, 75 tons capacity each.

108- Sets of intake service gates with guides, sills and fixed hoists, for the main units.

2- Sets of intake service gates with guides, sills and fixed hoists, for the house units.

168- Intake stop logs, for four units.

108- Sets intake trash racks, for the main units.

2- Sets intake trash racks, for the house units.

3- Sets of emergency trash racks. (Not to be installed)

36- Draft tube stop logs for four units.

196- Construction (draft tube) stop logs, for 32 main and 2 house units.

4- 75-foot ice gates and fixed hoists.

4- Sets 75-foot ice gate guides and sills.

2- 50-foot ice gates and fixed hoists.

2- Sets 50-foot ice gate guides and sills.

1- Set 75-foot ice ate stop logs.

4- Sets 75-foot ice gate stop log guides and sills.

1- Set 50-foot ice gate stop logs
2- Sets 50-foot ice gate stop log guides and sills.

(b) The material and equipment to be erected, except as noted below, will be furnished by the Government delivered on cars, f.o.b. site. These parts will include the major pieces of equipment as listed, together with their structural steel guides, sills, heating ducts, dogging equipment, lifting beams, crane collector bars and supports, castings, bearing plates, anchor bolts, machine bolts, field rivets and bolts, and other required fittings. The contractor shall furnish the construction plant and all field paint, grease, welding rods, tools, appliances and any other items incidental to handling, storing, erecting, painting and testing.

(c) The various parts will be completely fabricated in the manufacturers' shops insofar as economically feasible as determined by the contracting officer. All parts will be completely shop assembled and inspected for fit. The rivet and turned bolt holes will be reamed to full size and exact match, and the parts will then be disassembled, marked and match-marked. Small parts will be boxed and marked.

10-02. DRAWINGS.- The general arrangement of the material and equipment to be erected is shown on the drawings. Complete erection drawings will be furnished the contractor by the contracting officer.

10-03. WEIGHTS. - The approximate estimated weights of the various parts are listed below for the information of the contractor, but the Government will not be held liable for any claims or damage due to changes in the weights as finally ascertained:

Items	Net Weight for Each Unit, in Pounds	Heaviest part to be Handled, in Pounds
Powerhouse crane	600,000	120,000
Erection bay crane	200,000	50,000
Draft tube stop log gantry crane	30,000	10,000
Intake gate gantry crane	200,000	60,000
Intake service gate with guides and sill, main units	185,000	35,000
Intake service gate with guides and sill, house units	80,000	35,000
Intake service gate hoist	15,000	15,000
Intake stop logs	7,500	7,500
Trash racks, main units	70,000	23,300
Trash racks, house units	25,000	25,000
Trash racks, emergency	70,000	23,300
Draft tube stop logs	20,000	20,000
Temporary draft tube stop logs	14,250	14,250
75-foot ice gate	500,000	200,000
75-foot ice gate guides and sill	70,000	10,000
50-foot ice gate	275,000	110,000
50-foot ice gate guides and sill	60,000	10,000
75-foot ice gate stop logs	80,000	80,000
75-foot ice gate stop log guides and sill	35,000	10,000
50-foot ice gate stop logs	40,000	40,000
50-foot ice gate stop log guides and sill	30,000	10,000

10-04. DELIVERY. - The various parts to be installed under this contract will be delivered in advance of the probable date of their incorporation into the work. In the event that the parts are not shipped at a sufficiently early date, the time established for completion of this contract will be extended by an amount equal to the actual delay in construction of the work caused by the delayed shipment, as determined by the contracting officer.

10-05. UNLOADING AND HANDLING. - All material and equipment shall be carefully handled during unloading and placing in final position so that no parts will be bent, broken or otherwise damaged. Hammering or wedging that will distort or injure the members will not be permitted, and members shall not be overstressed during the process of unloading, handling and erection. The contractor shall unload all material promptly upon arrival at the site, otherwise he shall be responsible for demurrage changes and/or damages. He shall check all material turned over to him against shipping lists and report any shortage or damage as specified in paragraph 1-10(f). If the sequence of operations requires it, he shall store all material under cover and protect it from the elements until it is placed in final position.

10-06. TEMPORARY POWER. - Temporary electric power of the proper characteristics shall be supplied to the various crane feeders and hoist control boards as specified in Section I.

10-07. USE DURING CONSTRUCTION. - The contractor will be permitted to use all equipment, except powerhouse cranes (see below), that are installed under this section in doing any work for which such equipment is suitable on the condition that he provide competent operators and proper care for the equipment until the completion of the contract. Before the final payment is made, the contractor shall (if so ordered by the contracting officer) re-paint and re-test any or all pieces of equipment so used, and he shall make good any damage that may have resulted from the contractor's use thereof.

The powerhouse cranes will be operated by the Government (after acceptance), to facilitate erection of the turbines and generators under other contracts. The Government will also provide such crane service to this contractor and his subcontractors when necessary to move loads of 2,000 pounds and upward.

10-08. RIVETING AND WELDING. - Where riveting or welding of parts is required in the field, such work shall be done in accordance with the specifications therefor in Section VII where applicable. No riveting or welding will be required on trash racks, gates, stop logs or crane lifting beams.

The sills for the 75-foot ice sluice stop logs and the gate seal plates may be delivered in two parts and they shall be accurately aligned and welded together within the tolerances directed by the contracting officer and with the seal faces ground smooth.

Corrosion-resisting steel shall be welded in accordance with the best modern technique using columbium bearing welding rods and all welds shall be ground smooth. The welds on the heater chambers shall be watertight.

10-09. INSTALLATION OF EMBEDDED PARTS. - All embedded parts such as guides, sills, heating ducts and anchor bolts not furnished as part of the work covered in Section VII as structural steel, shall be set accurately to line and grade and securely held in place during concreting operations.

Templates shall be used for setting anchor bolts if necessary. Guides and guard angles may be installed when the concrete is placed or may be concreted into dovetail recesses left for them, but in any case the members, after embedment in the concrete, must conform to the tolerances established. The cost of additional forms to form recesses for these members and the extra cost of placing concrete or grout separately from the principal pour will not be paid for as a separate item but shall be included in the unit contract price for placing guides, etc., when such procedure is elected by the contractor. Recesses shall be left in the concrete for the installation of the guides for intake service gates and for all sills, as shown on the drawings. These members shall be carefully aligned and then concreted or grouted into place. (See paragraph 5-19.) Embedded parts shall be set carefully and accurately to the lines and elevations within tolerances directed by the contracting officer.

10-10. INTAKE SERVICE GATES. - The intake service gates will be wheeled gates, of structural steel and built in three sections, to be bolted together at the site. The gates will be equipped with rubber belt seals, "one-shot" greasing systems, locking dogs and fixed gate hoists. Splices in gates shall be bolted with tension and shear bolts for easy dismantling and the joints shall be made watertight with gaskets or bituminous material as directed by the contracting officer. The bolts in these splices will be turned bolts fitted into holes reamed in shop assembly and the contractor shall align the parts accurately, using at least four dowel pins at each splice. Grease piping shall be installed and secured in place across the splices and the wheel bearings shall be filled with grease. The rubber belt seals shall be fitted in place to form watertight joints. After all sections are spliced, the lifting devices shall be connected to the gate hoist for normal operation. Under no circumstances shall the gates be laid flat or tilted out of a vertical plane while the sections are coupled together. After final assembly, lines through the center of the wheel treads at each end of any gate shall be in the same plane and parallel to each other.

Dogs and operating devices which are required for all intake service gates will be shop fabricated insofar as possible and they shall be installed by this contractor as directed by the contracting officer.

10-11. SERVICE GATE HOISTS. - The service gate hoists including cables, control boards and all other parts shall be installed under this heading, except that all required grouting shall be done as specified in paragraph 5-19.

10-12. ICE GATES. - The ice gates will be of the fixed-wheel type and will be installed by the intake gantry cranes and operated thereafter by fixed hoists. It is intended that they will be fabricated and shipped in three sections each and that the horizontal field splices will be made with turned bolts in holes reamed in shop assembly. The provisions of paragraph 10-10 for installation of the service gates shall apply also to the ice gates.

10-13. TRASH RACKS. - The trash racks will consist of steel bars attached to a structural steel frame, delivered in completely fabricated sections. The emergency trash racks shall be placed in storage.

10-14. INTAKE AND ICE GATE AND DRAFT TUBE STOP LOGS. - The intake ice gate and draft tube stop logs will be built in sections with wood contact faces between sections. They will be shipped completely assembled and shall be installed in the guides as directed by the contracting officer.

10-15. DRAFT TUBE CONSTRUCTION STOP LOGS. - Draft tube construction

stop logs will be wood faced, steel frames delivered completely assembled in sections, and shall be installed in the slots or stores as required.

10-16. CRANES, LIFTING BEAMS AND COLLECTOR BARS. - The gantry and overhead cranes with lifting beams shall be installed on the runaways and the collector bars shall be placed in the proper position in slots provided. The contractor shall adhere to the best modern practice and workmanship in the erection of cranes, lifting beams, and collector bars and shall place all of his men working on the erection and testing, under the supervision and direction of the erection engineers furnished by the crane manufacturers. The services of the erection engineers will be paid for by the crane manufacturers. Crane lifting beams will be completely fabricated in the shop.

10-17. TESTS. - After installation, all parts requiring lubrication shall be greased with the proper type of lubricant as specified in paragraph 6-22. The centralized wheel greasing systems in all intake service gates and ice gates shall be checked and the wheel bearings filled with grease, using the portable grease pump furnished with the gates. All lubricants required shall be furnished by the contractor.

The gates shall be lowered into the slots and each gate tested by raising and lowering it several times throughout its full range. The dogging devices shall be tested by the operation of dogging each gate. Tests shall be repeated and necessary adjustments made in the gates, dogging assemblies and guides until the operation of all equipment is satisfactory to the contracting officer. After completion of tests, the intake service gates, ice gates, and trash racks shall be lowered to their normal positions and all stop logs stored as directed by the contracting officer.

Field tests of the completed cranes and lifting beams shall be performed by the contractor, as directed by the contracting officer. Tests shall include the normal functions for which the cranes and lifting beams are designed. The cranes shall raise, lower, hold in any position and transport on the runways at the specified speeds, test loads 25% in excess of their rated capacities and shall be operated far enough in each direction to test the operation of the limit switches.

10-18. MEASUREMENT AND PAYMENT. - Measurement for payment will be based on weights shown on the bills of lading for the material delivered and no addition will be made for the weight of field paint, field welds or temporary members supplied by this contractor to hold pieces in alignment during construction. The cost of all labor, plant and material (except material furnished by the Government) required to unload, store, transport, erect and test all parts as specified herein shall be included in the contract unit price for:

(a) "Installing Guides, Sills and Embedded Parts," per ton
(b) "Installing Gates, Stop Logs, Racks and Gate Hoists," per ton
(c) "Poured Grout," per cubic foot. (See also paragraph 5-19.)
(d) "Installing Gantry Cranes," per ton
(e) "Installing Overhead Cranes," per ton.

SECTION XI

PIPING

11-01. GENERAL. - The contractor shall furnish and install all metallic pipe, fittings, valves, sleeves, floor and roof drains and other similar items which are embedded in the concrete and other items associated therewith, as shown on detail drawings to be furnished at a later date, or as directed by the contracting officer. This section does not include grout pipes, sleeves for pipe handrail or pipe handrail, pipe used as temporary supports for other parts, electric conduit, or any items included elsewhere in these specifications. The future drawings will indicate pumps, large valves and other items of plumbing equipment, but such parts are not a part of the work under this contract unless their installation is necessary before removal of the cofferdams or unless specifically mentioned herein. Where such special items are shown partially embedded in the concreted, recesses shall be left for their installation under another contract.

11-02. MATERIAL. -

(a) Pipe and fittings shall conform to the provisions of Section VI as applicable.

(b) Gate Valves. Gate valves shall be of solid wedge pattern, with brass or bronze disk and double seat, and shall conform to Federal Specification WW-V-76b for "Valves, Gate; 125 Pound, Threaded and Flanged (For Land Use)", Type I. All valves shall be packed for their particular service and shall be 125 pound gate valves unless otherwise specified or noted. Valves 2 inches and less shall be brass body, Composition A or B, with non-rising stem; 2-1/2 inches and over shall have cast iron body, outside screw and yoke pattern except as otherwise noted on the drawings.

(c) Globe Valves. Globe valves shall conform to Federal Specification WW-V-51 for "Valves, Brass or Bronze; Angle and Globe, 150-pound, Threaded and Flanged (For Land Use)", Type 2, Globe, Composition A or B.

(d) Inserts for pipe hangers and similar uses shall be cast iron threaded concrete inserts similar and at least equal to Grinnel No. 151.

(e) Miscellaneous Material. Where materials are shown on the drawings but are not specifically covered herein by detail specifications, the contractor shall furnish high-class commercial grades of materials or articles that are satisfactory to the contracting officer.

11-03. WORKMANSHIP. -

(a) The contractor shall install all the work in a first class manner. Pipe and other parts embedded in concrete shall be held in place securely to avoid displacement during pouring. In general, the contractor shall locate and set sleeves, inserts and similar parts necessary to complete the various systems under another contract when such work is directed by the contracting officer. Ends of pipe shall be plugged or capped at completion of the work or at other times, as directed, to prevent clogging.

(b) Pipe shall be laid accurately to line and grade without traps, and lines shall be pitched to drain as directed.

(c) All piping shall be erected using unions located so that piping can be removed for repair or replacement without removing an excess amount of piping. The contractor shall make adequate provision for expansion and contraction of piping.

(d) All pipes shall be supported at intervals not to exceed ten feet for 2 inch pipe and larger, and not to exceed fifteen feet for smaller sizes. All hangers shall be set to clear electrical fixtures by at least 12 inches. Where three or more pipes run parallel and pitch in the same direction, bar hangers shall be used. In general, all hangers and supports shall be properly designed and adapted for their particular use; light or inadequate members such as wire, perforated strap hangers or wood posts will not be permitted except where light metal ties are used to hold pipe in place during concreting.

(e) The contracting officer reserves the right to rearrange the piping systems, or to make minor changes in the location of piping, such as re-alignment necessary to clear important conduit runs or other unforseen obstructions, without change in the unit contract prices.

(f) All threads on pipes are to be cut true and clean and screwed up tight in fittings, using red lead and oil or other approved pipe joint cement. All joints in bell and spigot cast iron pipe are to be made up with oakum and lead, caulked tight, except that joints in Duriron pipe shall be made in accordance with the manufacturer's recommendations. Flanged joints shall be brought up tight using approved asbestos composition gaskets, Crane Company "Cranite", or equal. Glyptal (red) or equal shall be used on joints in oil piping. Joints in copper tubing shall be made according to methods recommended by the manufacturer of the pipe or fittings. Where the type of pipe changes (as from flanged to bell and spigot), approved adaptors or transition sections shall be used.

(g) All pipes shall be cut accurately to measurements established at the structure by the contractor. All threaded pipe shall be reamed after cutting and before threading to remove all burrs. All pipes shall be installed in a neat and workmanlike manner. To perform this work, the contractor shall install at the site a pipe threading and cutting machine capable of handling the largest size of screwed pipe specified. He shall also provide a complete set of plug and ring gages.

11-04. PIPE LAID IN TRENCHES. - All water, oil and air piping buried in trenches shall be black wrought iron pipe, with galvanized malleable iron fittings. All such pipe used for oil lines shall be pickled. The outside of the pipe and fittings shall be protected, after placing, with two heavy coats of asphalt paint.

11-05. WATER LINES. - All cold water piping for raw and treated water and fire lines, where exposed, shall be wrought iron pipe. Fittings in sizes 3 inches and less shall be screwed malleable iron; over 3 inches they shall be cast iron flanged fittings. Pipe under 6 inches which is embedded in the concrete, or otherwise inaccessible, shall be black steel with fittings as specified for the like sizes of exposed piping. Embedded pipe and fittings 6 inches and larger shall be cast iron bell and spigot.

All hot water and drinking water piping shall be copper tubing, Type L, with brass or copper solder fittings and brass gate valves.

11-06. SANITARY WASTE AND VENTS.

(a) Plumbing Drains. - All plumbing drains embedded in concrete or otherwise inacessible and exposed lines 4 inches and larger shall be cast iron bell and spigot pipe and fittings. Exposed lines 3 inches and less shall be galvanized steel pipe with cast iron screwed drainage pattern fittings and screwed, galvanized malleable iron unions.

(b) Cleanouts. An adequate number of cleanouts, the full size of the pipe, shall be located in accessible places as directed by the contracting officer. They shall conform to the Federal Specification cited in paragraph 6-17 (d), with raised or countersunk head depending upon location, iron body ferrules and screwed brass plugs.

(c) Plumbing Vents shall be black steel pipe with malleable iron, screwed fittings except that pipe and fittings embedded in concrete or otherwise inaccessible and all unions shall be galvanized.

11-07. UNWATERING SYSTEM. All pipe and fittings for the unwatering systems, where embedded in concrete, shall be cast iron bell and spigot. Exposed pipe shall be black steel with cast iron screwed drainage pattern fittings for 6 inches and smaller sizes, and cast iron flanged fittings for 8 inches and larger.

11-08. GENERAL DRAINS. -

(a) Material. Pipe for all drains (except acid and plumbing drains) shall be galvanized steel. Fittings 6 inches and larger shall be cast iron flanged, and fittings less than 6 inches shall be cast iron drainage pattern, screwed. Unions 3 inches and less shall be galvanized malleable iron.

Acid drains, where directed, shall be Duriron pipe and fittings.

(b) Cleanouts for roof drains shall be located as directed by the contracting officer. They shall be similar to cleanouts in the plumbing drains, except that cleanouts larger than 6 inches need not be used for the larger size pipes.

11-09. AIR LINES. - All air pipe shall be black steel with malleable iron fittings, except for under-ground lines specified in paragraph 11-04. Valves for hose outlets shall be brass, globe type, equipped with standard air hose couplings. All other valves shall be brass gate valves. All pipe, fittings and valves shall be standard weight except that where 300 pound pressure air systems are used, pipe shall be Class B, extra heavy, with "300 pound class" fittings and valves.

11-10. OIL LINES. - All oil pipes shall be pickled wrought iron pipe. In general, all fittings shall be pickled wrought iron with all joints welded, except that galvanized malleable iron screwed fittings and unions may be used where space limitations make welding difficult and when such substitution is approved by the contracting officer.

11-11. CARBON DIOXIDE SYSTEM. All pipe for the carbon dioxide fire protection system shall be galvanized steel, standard weight for pipe less than 1 inch, and extra heavy for 1 inch and larger. Fittings and unions on lines 2 inches and less shall be 300 pound

type, galvanized malleable iron. Fittings on lines over 2 inches shall be at least 300 pound type, forged steel flanged.

11-12. MISCELLANEOUS PIPING.

(a) Scroll Case Vents shall be welded, black steel pipe made with 1/4 inch plate in accordance with the specifications of the American Society of Testing Materials, Serial Designation A 134-39 or A 139-39. All field joints shall be welded.

(b) Headwater and Tailwater Gage Wells shall be black steel pipe with cast iron flanges.

(c) Net Head and Flow-recording Pipe shall be iron-pipe-size brass with screwed brass fittings, unions and gate valves.

(d) Manometer Drain shall be black steel pipe with malleable iron screwed fittings and unions.

(e) Soap pipe shall be iron-pipe-size brass with brass screwed fittings and unions.

11-13. ROOF AND DECK DRAIN HEADS. -

(a) Roof Drain Heads shall be cast iron japanned body with removable dome strainer equipped with a clamping ring to hold roofing or flashing, or a flashing flange. The heads shall be of the proper type for the surface in which they are installed, equipped with expansion joints, similar and at least equal to Zurn Figure Z-120 or Holt Type 6. (For payment see paragraph 11-18 (n)).

(b) Exterior Deck Drains shall be cast iron, japanned body with removable bronze or brass strainer, similar and at least equal to Zurn Figure Z-500 or Josam Series 510. (For payment see paragraph 11-18 (o)).

11-14. FLOOR DRAINS. -

(a) Floor drains in toilet and shower rooms shall be iron body with adjustable chromium-plated brass strainers. The drains in the shower rooms shall have clamping rings. The general type shall be similar and at least equal to Zurn Figure Z-250 or Josam Series 250 ADC. (For payment see paragraph 11-18 (o))

(b) Except as specified otherwise, all floor, sump and pit drains below the turbine room floor level shall be cast iron, bell trap floor drains similar and at least equal to Clow-National F-3935 or Crane C-34-626-A. (For payment see paragraph 11-18(p))

(c) Trench drains shall be coated cast iron with removable strainers, similar and at least equal to Zurn Figure 575 or Josam Series 1500. (For payment see paragraph 11-18 (p))

(d) All other floor drains, including those in the oil room, shall be cast iron body with removable brass strainer and traps. Drains shall be similar and at least equal to Zurn Figure Z-560 or Josam Series 70, with standard U-traps. (For payment see paragraph 11-18 (o))

11-15. INSERTS AND SLEEVES.

(a) Where pipes pass through floors or walls, the contractor shall set black steel or galvanized iron pipe sleeves. Steel sleeves shall be cut accurately to length and the ends shall be ground

smooth. The type, size, projection and length of sleeves shall be determined by the contracting officer.

(b) When, in the opinion of the contracting officer, it is advisable to set sleeves or inserts in the concrete for piping to be installed under another contract, this contractor shall set such parts as directed.

11-16. TESTS.

(a) General. - Where extensive sections of systems of piping are installed completely or where such procedure is advisable before lines are buried in trenches, the contractor shall perform tests when so directed by the contracting officer. In general, tests may be applied to an entire system or in section. Sections which have been found satisfactory need not be re-tested after completion of the entire system unless considered necessary by the contracting officer. Should the tests indicate excess leakage or any other defect, the contractor shall make adequate repairs or replacements. Air tests shall take into account changes in temperature and atmospheric pressure during the tests.

Before any tests are undertaken, the contractor shall notify the contracting officer so that such tests may be witnessed by him or his authorized representative.

The contractor shall furnish all labor, material and equipment necessary for performing all tests, the cost of which shall be included in the applicable unit contract prices.

(b) Soil, Waste, Vent and Drain Piping. Soil, waste, vent and drain piping shall be tested with air pressure. The air test shall be made by attaching a compressed air connection to any suitable opening and closing all other inlets and outlets to the system by means of proper testing plugs. Air shall be forced into the system until there is a uniform pressure of 5 pounds per square inch on that portion of the system being tested. The pressure shall remain constant for 20 minutes without the addition of air.

(c) Supply Piping. The water supply system, both cold and hot, shall be tested with air at a pressure of 75 pounds per square inch. The pressure shall remain without appreciable drop for 24 hours without the addition of air.

(d) Air Lines. The compressed air system shall be subjected to an air test equal to the designed pressure for each system. Each system shall be filled with air at the specified pressure and shall maintain this pressure without appreciable drop for a period of 24 hours without the addition of air.

(e) Oil Piping. Oil piping shall be tested with air pressure at 100 pounds per square inch in the same manner as tests of the compressed air piping. Pipe buried underground shall be tested before backfill is placed.

(f) Soap Piping. Soap piping shall be tested with air at 50 pounds pressure in the same manner as specified for air lines.

(g) Carbon Dioxide Piping. Carbon dioxide piping shall be tested as recommended by the manufacturer of the equipment.

(h) Payment. No separate payment will be made for testing; the cost thereof shall be included in the applicable unit prices.

11-17. MEASUREMENT FOR PAYMENT. - Measurement for payment for pipe, fittings and other items in this section where payment is based on weight, shall be the nominal weight of the actual pipe of fittings installed, not including paint, joint material, or waste, all such items being

absorbed in the unit price for the pipe or fittings installed.

11-18. PAYMENT. - The cost of supplying all labor, plant and material necessary to furnish and install all piping, as specified or directed, shall be included in the contract prices for the separate items of work, as follows:

(a) "Steel Pipe and Fittings, Black", per lb. This includes 1/4 inch plate welded steel pipe.
(b) "Steel Pipe and Fittings, Galvanized", per lb.
(c) "Wrought Iron Pipe and Fittings", per lb. (See also paragraph 5-18(f)(8))
(d) "Pickled Wrought Iron Pipe and Fittings", per lb.
(e) "Cast Iron Pipe and Fittings", per lb. This includes bell and spigot, screwed and flanged types.
(f) "Duriron Pipe and Fittings", per lb.
(g) "Forged Steel Fittings", per lb.
(h) "Coating Underground Pipe and Fittings", per lb. of pipe and fittings.
(i) "Brass Pipe and Fittings", per lb.
(j) "Copper Tubing and Fittings", per lb.
(k) "Inserts, Pipe Hangers and Supports", per lb.
(l) "Brass Valves", per lb.
(m) "Iron Body Valves, Brass or Bronze Mounted", per lb.
(n) "Roof Drains", per lb.
(o) "Floor and Deck Drains, Brass or Bronze Strainers", per lb.
(p) "Floor and Trench Drains, all C.I", per lb.

SECTION XII

ROOFING AND COPPER METAL WORK

12-01. WORK INCLUDED.

Under this section, the contractor shall furnish and install all roofing and similar work which, in general, includes the following items:

Precast concrete roof slabs, complete with bolts and clips
Interlocking precast concrete roof tile
Asphalt roofing
Copper flashing, counter flashing and gutters.
Lead collars

12-02. ROOF SLABS.

(a) Material.

(1) Roof slabs shall be precast concrete channel slabs, similar and at least equal to Federal-American Cement Tile Company's "Featherweight" Concrete Channel Roof Slabs, made with light weight aggregate similar to "Haydite" or "Pottsco."

(2) The roof slabs shall be reinforced with wire mesh accurately placed and shall be designed for an ultimate load of 250 pounds per square foot uniformly distributed over a maximum span not in excess of eight feet.

(3) Slabs shall be as nearly perfect as good workmanship will permit; cracked, broken or warped slabs will not be accepted. Slabs shall be of dimensions and shapes suitable for their particular use with channels bearing on the purlins. Special shapes shall be cast for special conditions if necessary.

(4) Provision shall be made to clip the slabs securely to the purlins at two or more points per full size slab (one on each end.) Such clips shall be sufficiently strong to resist a gross uplift of 20 pounds per square foot using stresses not more than one fifth of the ultimate strength of the material used. Bolts, threaded inserts or other approved anchors for the clips shall be cast into the slabs. The steel clips, inserts, bolts, nuts, washers and other parts shall be hot-dipped galvanized after forming and cutting.

(b) Installation.

(1) All slabs shall be erected by or under the supervision of the manufacturer, in a thorough workmanlike manner. Slabs shall be laid on the purlins with joints matching closely and clipped securely in place.

(2) All joints between slabs shall be cemented on the upper side with an approved brand of asphaltic cement and the finished deck shall present a smooth surface ready for the application of composition or other covering.

(3) The slabs under gutters need not be clipped to the steelwork. Joints between these slabs and supporting members shall be closed off to prevent objectionable leakage when the concrete or fill is placed on top of the slabs.

(c) Tests. - The contractor shall furnish sample slabs for test purposes amounting to not more than two per cent of the total quantity re-

quired for the work. Slabs for testing will be selected by the contracting officer at the manufacturer's plant and tested by the Government at the Government's expense.

12-03. INTERLOCKING CONCRETE SLABS.

(a) Material.

(1). Interlocking precast concrete roof slabs shall be similar and at least equal to Federal-American Cement Tile Company's "Featherweight" Interlocking Slabs. The top surface of the slabs shall present a smooth, dense surface highly resistant to action of the elements, free from crazing or spalling and without any porous aggregates on the surface that would be affected by freezing.

(2) The exterior surface shall show a uniform red color, permanent and not subject to bleaching, and the color shall penetrate the top 1/2 inch of the concrete (at least.).

(3) Except as specified above, and except that the purlin spacing will be not greater than 4 feet, the slabs shall conform to the requirements of paragraph 12-02 (a).

(4) All trimmings such as ridge rolls and ventilator collar slabs shall conform to these specifications.

(5) Elastic compound, oil cement and all other incidental materials used shall be in accordance with the tile manufacturer's recommendations, they shall have a satisfactory record of performance over a period of years in localities with similar weather conditions and they shall be subject to the approval of the contracting officer.

(b) Installation.

(1) All slabs shall be erected by or under the supervision of the manufacturer, in a thorough workmanlike manner. Slabs shall be laid on the purlins with the joints matching closely and securely clipped in place.

(2) Slabs shall be laid with staggered ridge joints normal to the slope and in true, straight lines meeting at all hips and valleys. The longitudinal joints shall be cemented with oil cement and a weather cap coat of elastic compound of a color that will match the tile at the time of installation and that will neither darken nor fade with age and exposure. The lap or cross joint shall be amply wide and shall be a squeeze joint of oil cement.

(3) Ridge and hip rolls shall be cemented together in a manner similar to the main roof slabs. All such pieces shall be securely attached by nailing to a creosoted wood member which shall be bolted to the steel work.

(4) The row of tile adjacent to the parapet wall shall be precast concrete nailing slabs similar and at least equal to Federal American Cement Tile Company's "Featherweight" Nailing Concrete Roof Slabs. Cant strips and copper sheathing will be installed over these slabs to form gutters.

(c) Tests. - Tests shall be the same as specified for concrete roof slabs in paragraph 12-02 (c) hereof.

12-04. ASPHALT BUILT-UP ROOFING.

(a) Installation.

(1) The contractor shall install 20 year bonded asphalt roof where this type of roof is shown on the drawings. Materials, workmanship, number of layers and weights of felt and all other details shall be in accordance with the manufacturer's specifications.

(2) Where required or directed, the roofing shall be turned up onto the wall or carried into the reglet in an approved manner, using felt suitable for this purpose.

(3) The roofing shall be furnished by an established manufacturer and installed by a contractor bonded by the manufacturer and under his supervision, both subject to the approval of the contracting officer.

(b) Guarantee. The contractor shall, upon completion of the work, provide the Government with a surety bond in the full amount of the cost of the built-up roofing and in a form satisfactory to the contracting officer, which shall stipulate at least that the contractor shall, during a period of twenty years after and commencing on the day of acceptance of the work, maintain the roof watertight, and repair all defects caused by faulty workmanship or material, or ordinary wear and tear, without cost to the Government.

12-05. METAL WORK.

(a) Material. - All sheet copper and sheet lead shall conform to the requirements of Section VI.

(b) Flashing.

(1) All copper used for gutters, flashing, counter flashing, joint seals and similar places shall be of sizes specified and shall weigh al least 16 ounces per square foot. All seams shall be flat or double locked and well soldered. Extreme care shall be exercised so that no copperwork is punctured or bent out of place and any such defects shall be repaired in a satisfactory manner.

(2) Flashing shall be mopped in place under the roofing. Flashing or counter flashing shall be carried into the reglet the full depth and shall be turned back to form a hook and thoroughly secured by hammering lead wool in place or with elastic roofing cement.

(3) Roof drains and exhaust outlets shall be flashed into the roofing, using copper sheets in accordance with details to be shown on the construction drawings or as directed by the contracting officer.

(4) Toilet vent stacks will be 4 inches in diameter and will project 12 inches above the roof. A sheet lead collar, weighing not less than 6 pounds per square foot, shall be turned down into the pipe at the top and shall be mopped into the roofing at the bottom, and extend at least 8 inches under the roofing.

(c) Copper Gutter. Copper gutter around the concrete tile roof shall be of the same weight as the flashing, with all joints fastened to form a secure and watertight gutter. Copper shall cover the entire lower row of tile (nailing slabs) and be sealed into the longitudinal joint. Immediately before laying the copper, the contractor shall cover the top of the nailing slabs with a heavy mopping of hot asphalt. The roof shall be nailed in place using copper nails spaced not more than 6 inches on centers and in rows not more than 24 inches on centers. The completed deck shall form an absolutely watertight surface, free from bulges or exposed edges, and tight to the concrete deck.

12-06. CANT STRIPS AND FILL. -

(a) All fill for cant strips, saddles and gutters shall be composed of equal proportions of gypsum and wood shavings mixed with water and applied on top of the roof slabs. The contractor shall mop with asphalt over the roof deck before placing the fill and shall also mop on top of the fill before placing roofing or copper.

(b) Cant strips and full will not be paid for as such, and the cost of furnishing and placing shall be included in the unit contract price for each type of roofing.

12-07. CHANGE IN DESIGN OF ROOF.

(a) The contracting officer reserves the right to revise the design of the sloping roof over the power house by substituting therefor an approximately flat roof similar to those shown in other locations (as on drawing sheet 21). Such substitution may be made at any time before the contractor has ordered the structural steel and for this reason the contractor shall notify the contracting officer in writing at least ten days before he intends placing the order for structural steel.

(b) This substitution will increase the quantities for payment under certain contract items under this section and decrease or eliminate others, but such change in quantities shall not alter the unit contract prices.

12-08. MEASUREMENT FOR PAYMENT.

Measurement for payment for roofing and roofing slabs shall be based on the areas of roof actually covered, using horizontal or slope dimensions or surfaces with no deductions for openings less than 15 square feet in area. The vertical height of flashing or roofing from the deck to the reglet shall not be added to the net roof area but the cost of such work shall be included in the unit cost of the roof.

12-09 PAYMENT. - The cost of all labor, plant and material required to furnish and install all precast concrete roof slabs, roofing and metal work specified in paragraphs 12-01 to 12-06 inclusive shall be included in the contract unit prices for:

(a) "Precast Concrete Roof Slabs" per square.
(b) "Precast Concrete Roofing Tile" per square.
(c) "Built-up Asphalt Roofing" per square.
(d) "Copper Metal Work" per pound. (See also paragraph 5-21(e))
(e) "Lead Collar for 4 inch Toilet Vent," each.

SECTION XIII - PAINTS AND PAINTING

13-01. GENERAL. - The requirements set forth in this section include both shop and field cleaning and painting. Unless otherwise specified or authorized, all paint materials shall conform to the current Federal Specifications wherever applicable. Where Federal Specifications are not applicable, material shall be as specified, or otherwise subject to the approval of the contracting officer. All colors shall be as specified or subject to the approval of the contracting officer. All paint, when applied, shall provide a satisfactory film and a smooth even surface, except when sand reinforced, and undercoats shall dry without excessive gloss, suitable for the proper application and adhesion of subsequent coats, as approved by the contracting officer. Where necessary, in the opinion of the contracting officer, to suit the conditions of surface, temperature, and weather existing at the particular time of application, the packaged paint may be thinned by the addition of not more than one pint per gallon of mineral spirits (paragraph 13-10(a)) immediately prior to application, provided that in no case shall the viscosity of the paint be reduced to a point where the specified maximum coverages will be exceeded. To distinguish several paint coats of the same color the contracting officer may require the addition of carbon black to give each coat a different shade.

13-02. SURFACE CLEANING PREPARATION.

(a) Shop Cleaning. - Unless otherwise specified all ferrous surfaces to be painted, which will be subjected to continuous or occasional submergence, or which will be repeatedly wet from water condensation, shall be thoroughly cleaned of all millscale and other foreign substances to base by sandblasting, or any other method approved by the contracting officer. All other exposed metal surfaces to be painted shall be thoroughly cleaned of all loose millscale and other foreign material by wire brushing and/or flame cleaning.

(b) Field Cleaning. - Unless otherwise specified all painted ferrous surfaces, which will be subjected to continuous or occasional submergence, or which will be repeatedly wet from water condensation, shall be cleaned of paint, rust and dirt by sandblasting. All other painted surfaces to be repainted shall be cleaned of dirt, oil and other foreign substances by the use of mineral spirits or other approved cleaning agents immediately prior to the application of field coats. All blisters and breaks in the paint film shall be cleaned to base surface by wire brush or scraper.

(c) Protection of Surfaces. - Care shall be taken to adequately protect all machinery parts, threads, and finished surfaces during cleaning and preparation.

(d) Inhibition. - No shop inhibitive treatment will be required. All surfaces cleaned in the field by sandblasting, or equally effective method, shall be treated with a chemical rust inhibitor (paragraph 13-07). The inhibitor shall be applied as soon after cleaning as practicable, and prior to formation of any form of corrosion from atmospheric moisture, or other causes. The inhibitor shall be applied by brush and permitted to dry. This chemical inhibitor, however, shall be applied only under conditions such that the temperature of the surfaces to which applied and the air in contact therewith, are between 50 degrees F. and 110 degrees F., in

order to insure proper chemical reaction with the metal. After drying, any unneutralized reactive residue on the surfaces shall be removed by thorough wiping with wet cloths. The inhibited surfaces shall then be permitted to dry thoroughly and shall be brushed with a broom to remove the dry dusty reaction product, after which a standard priming coat of paint, as indicated, shall be applied as soon as practicable, but in any event prior to deterioration or destruction of the inhibited surface. Should the inhibited surface be damaged, the surfaces shall be cleaned and retreated in approved manner prior to application of the paint.

13-03. PAINT APPLICATION.

(a) All painting shall be done in a neat, thorough, and workmanlike manner. Except where other wise specified or specifically directed, all paint coats shall be applied by either brush or spray in such manner as to produce an even coating of uniform thickness completely coating all corners and crevices. All painting shall be done by thoroughly experienced workmen. Care shall be exercised during spraying to hold the nozzle sufficiently close to the surfaces being painted to avoid excessive evaporation of the volatile constitutents and loss of material into the air. Paint shall be applied only to surfaces that are thoroughly dry and only under such combination of humidity and temperatures of the atmosphere and surfaces to be painted as will cause evaporation rather than condensation. A practical test is to wipe a damp cloth on the surface to be painted. If the moist streak dries promptly, conditions conducive to evaporation prevail. In no case shall any paint be applied to surfaces upon which there is frost or moisture condensation, or during rainy or misty weather, without suitable protection as approved by the contracting officer. Painting during unfavorable weather conditions shall be carried on under a protective covering erected for this purpose. While any painting is being done, the temperature of the surfaces to be painted and of the atmosphere in contact therewith shall be maintained at or above 50 degrees F. All paint when applied shall be approximately (within fifteen degrees of) the same temperature as that of the surface on which it is applied. Where protection is provided for paint-surfaces, such protection shall be preserved in place until the paint film has properly dried and removal of the protection authorized by the contracting officer. Items which have been painted shall not be handled, worked-on or other wise disturbed until the paint coat is completely dry and hard. After delivery at the site of permanent erection or installation, all shop-primed metal work shall be kept clean and free from corrosion. The surfaces shall be repainted or retouched from time to time, when in the opinion of the contracting officer it becomes necessary, using the same type of paint as the priming coat. Where field-painting at the site has been commenced on any portion of the work, the complete painting operation, including priming and finishing coats, on that portion of the work, shall be completed within 30 days after the date of such commencement. All coats on all painted surfaces shall be unscarred at the time of application of all succeeding coats, and when in the opinion of the contracting officer it becomes necessary, all coats shall be maintained by retouching or repainting, using the proper paints for the respective coats. After completion of painting, all glass, woodwork, and hardware and other surfaces not required to be painted shall be cleaned to the satisfaction of the contracting officer.

(b) Coverage. - The surface area covered per gallon for each type of paint specified shall be not greater than the following:

On smooth metallic surfaces:

1st priming coat	600 square feet
2nd priming coat	425 square feet
1st and 2nd finish coats	550 square feet

On sanded priming coat:

Sanded primer coat	425 square feet
1st finish coat	250 square feet
2nd finish coat	300 square feet
3rd finish coat	400 square feet

13-04. PRIMING COATS

(a) Unpainted Surfaces. - The surfaces of all ferrous metal work to be embedded in the concrete, machined surfaces, surfaces requiring welding, and surfaces which will be in riveted contact shall not be painted unless otherwise specified.

(b) Shop Priming.

(1) Unless otherwise specified all exposed ferrous metal shall receive one shop coat of Synthetic Red Lead Primer.

(2) Machined surfaces shall, immediately after final inspection, be thoroughly cleaned of all foreign matter and coated with Rust Preventive Compound, U. S. Army Specification 2-84A.

(3) Screw threads shall be protected by a coating of heavy oil.

(c) Field Priming.

(1) All ferrous surfaces from which the priming coat has been sandblasted shall be treated as follows: the surfaces shall be inhibited and painted with one coat of Synthetic Red Lead primer. In this coat, a heavy uniform course of perfectly clean sand (see paragraph 13-11 (f)) shall be thoroughly and uniformly embedded within 15 minutes after application of the paint, or in any event before the paint has set to such extent as to prevent the proper embedment and adhesion of the sand particles. The sand shall be applied by air spray at reduced pressure or in any other manner which will insure thorough embedment of the maximum volume of sand particles without appreciable movement of the paint film. This coating shall be allowed to dry for a minumum of 48 hours prior to application of finish coats.

(2) All other surfaces shall receive a second priming coat of Synthetic Red Lead Primer after final erection in place in the structure. Surfaces which will be inaccessible after erection shall be painted prior thereto.

13-05. FINISH COATS.

(a) General. - Unless otherwise specified, or authorized, the sand reinforced primed metal shall be given three coats of Gray Finish Enamel (see paragraph 13-06(d)). Exposed primed surfaces of all other metal work shall receive two coats of Gray Finish Enamel. The priming coat over which it is applied shall be thoroughly dry and hardened, and at least a 24-hour interval shall be allowed between two successive finish coats and not less than 5 days for hardening of the final coat before being submerged in water. In any case, all finish painting shall be completed within 30 days after application of the first field priming coat.

(b) Piping. - All exposed black steel or black wrought iron

pipe and fittings shall be cleaned by wire brushing and given one coat of Synthetic Red Lead Primer on the outside. All exposed pipe shall be marked with patches of an approved, colored enamel paint for temporary identification in the following colors:

Oil	Green
Air	Yellow
Raw Water	Gray
Treated Water	----
Carbon Dioxide	Red

13-06. PAINTS AND PAINT FORMULAE.

(a) General. - Paints shall have the composition as indicated below and shall be of a color matching the color clips attached or as otherwise approved by the contracting officer. All paints shall be guaranteed by the manufacturer not to gel, liver or thicken deleteriously or form gas in a closed container within a period of one year from date of manufacture.

(b) Processing of Paints.

(1) Except where otherwise specified or authorized, all paint shall be made by grinding together dry or paste pigments and a liquid vehicle to form a smooth paint that will flow freely and will not settle or react deleteriously in containers.

(2) Grinding shall produce a fineness such that coarse particles and skins will not exceed 1.5 percent (total residue left on No. 325 mesh screen, based on pigment). The grinding shall be done in a roll or pebble mill at temperatures that will not cause polymerization.

(3) Skinning shall be negligible after exposing 6 ounces of paint in a tightly closed 8 ounce glass container to sunlight for a total time of 24 hours.

(4) The resulting paint shall have satisfactory brushing and leveling properties, shall set to touch in not less than one hour nor more than four hours, unless otherwise specified, and shall provide a satisfactory film and a smooth even surface without undue gloss, suitable for proper application and adhesion of subsequent paint coats, as approved by the contracting officer. Sufficient suitable driers shall be added to made the paint dry hard within 18 hours.

(5) In view of potential variations resulting from variable processing equipment and technique, the manufacturer may be allowed, where necessary to produce the specified viscosities, to make slight changes in formula proportions, subject to specific approval of the contracting officer.

(c) Synthetic Red Lead Primer. - Synthetic Red Lead Primer to be used under all gray enamel finish coats shall be composed of materials conforming, where applicable, to the specified requirements and mixed in the proportions as follows:

Red Lead	16.5% by weight
Iron Oxide	38.2%
Zinc Yellow	5.5%
Diatomaceous Silica	6.0%
Vehicle (see paragraph 13-08)	28.0%
Thinner	5.8%

The paint shall have a consistency of flow of between 25 and 40 seconds through the 0.15 inch diameter orifice of a standard consistency cup when tested in accordance with the procedure specified in paragraphs 9 and 10 of

A.S.T.M., Specification D 333-37 for "Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels." It shall have satisfactory brushing and leveling properties, shall set to light touch in not less than two hours nor more than five hours, and shall dry hard for recoating in not more than 18 hours, when tested in accordance with paragraph F-2d of Federal Specification TT-V-81a, entitled "Varnish; Mixing (for) Aluminum Paint." The vehicle shall be a synthetic resin varnish consisting of phenol formaldahyde resin with the necessary oils and volatile thinners to produce elasticity, water-proofness, adherence, and durability in the finished paint film. It shall meet the detailed requirements of paragraph 13-08.

(d) Gray Finish Enamel. - Unless otherwise specified, all finish paint for all metal surfaces shall have the following composition and properties:

Coloring pigments	0.5 lbs. (approx.)
Lead Titanate	3.0 lbs.
Magnesium silicate	1.0 lbs.
Acicular Zinc Oxide	0.25 lbs.
Vehicle (see paragraph 13-08)	1.0 gallon

The paint shall have a consistency of flow of between 18 and 40 seconds through the 0.15 inch diameter orifice of a standard A.S.T.M. consistency cup. The enamel shall have good self leveling properties and when brushed or sprayed on a vertical surface at a coverage rate of 500 square feet per gallon shall dry hard and elastic without running, streaking or sagging.

(e) Gray Heat Resistant Primer and Finish Paint for Metal. - Gray heat resistant primer and finish paint for metal shall have the following composition:

Coloring Pigments	1.0 pound (Approx.)
Titanium Dioxide	3.0 pounds
Vehicle	1.0 gallon

Drier - sufficient approved driers to made the paint dry hard in 10 hours.

The vehicle shall be a glycerol-phthalate resin varnish of the following composition:

Glycerol-Phthalate Resin Solution	3/4 gallon
Mineral Spirits	1/4 gallon

The glycerol-phthalate resin solution shall consist of 70 percent by weight of glycerol-phthalate resin dissolved in 30 percent by weight of xylol and shall be similar and equal to "Rezyl" No. 110, Solution No. "C," as manufactured by the American Cyanamide & Chemical Corporation, 30 Rockfeller Plaza, New York, N. Y.

13-07. CHEMICAL RUST INHIBITOR. - Chemical rust inhibitor, to be used where specified or required, shall be an approved compound of water, a wetting agent, a viscosity agent, phosphoric acid, and sodium dichromate. The concentration of the solution at the time of application shall be such that the Ortho-phosphoric acid (H_3PO_4) content shall be between 7.0 and 9.0 percent (by weight) and the Sodium Dichromate approximately 0.75 percent. Commercial chemical rust inhibitors of composition somewhat different from this may be acceptable in lieu thereof, subject to approval by the contracting officer of results of approved tests showing that the inhibitor, when applied in accordance with instructions of the manufacturer, will identically affect ferrous surfaces as the specified compound in the following

ways:

(a) Chemically react with rust and surface metal to etch the surface, form a dull grayish coating of iron-chromate-phosphate, and produce a rust-inhibited surface receptive to the firm bonding of the priming paint.

(b) After initially being thoroughly dried, the inhibited surface shall show no deleterious rusting when subject to light rain or to other dampening agency for a period of not less than 4 hours.

(c) Leave no unneutralized active chemicals on the surface.

13-08. PHENOLIC RESIN VARNISH VEHICLE. - Phenolic resin varnish vehicle shall conform to the following requirements:

(a) Oil-resin ratio shall be 33 gallons of oil to 100 pounds of resin.

(b) Shall be clear and transparent and entirely free from resin, estergum or other non-phenolic resins. Not less than 50 percent by weight of the vehicle shall consist of non-volatile oil and resin.

(c) The resin content shall be 100 percent para phenyl phenol-formaldehyde condensate similar and equal to Bakelite BR 254, and shall conform to the current U. S. Navy Department Specification 52R10 entitled "Resin Phenol-Formaldehyde."

(d) The volatile thinner shall contain not more than 80 percent mineral spirits and not less than 20 percent high flash coal tar naptha or high flash hydrogenated petroleum naphtha and shall be free from toxic hydrocarbons such as benzol.

(e) The oil content shall be a ternary oil mixture composed of 40 percent linseed, 30 percent liquid oiticica, and 30 percent "dehydrated" castor oil.

(f) The flash point shall be not below 30 degrees C. in a closed cup tester.

(g) Shall pass a Kauri Reduction Test of 120 percent, using the method described in paragraph F-2g, Federal Specification TT-V-81 for "Varnish; Mixing (for) Aluminum Paint."

(h) Shall show no skinning after 48 hours in a 3/4 filled, tight container.

(i) Flow-out films on tin plate panels dried 72 hours shall withstand immersion in cold water for 96 hours, and in distilled water at 200 degrees F. for 7 hours without showing more than a slight haze which shall disappear within one hour, and shall show no other signs of deterioration. The panel shall be allowed to dry and cool for 15 minutes after removal from hot water and shall then be inspected for signs of failure.

13-09. PIGMENTS.

(a) Carbon Black shall conform to either Federal Specification TT-B-601, entitled "Boneblack; Dry, Paste-in-Japan, Paste-in-Oil" or Federal Specification TT-L-71 entitled "Lampblack; Dry, Paste-in-Japan, Paste-in-Oil."

(b) Lead Titanate shall be similar and equal to Titanox "L" as manufactured by the Titanium Pigment Corporation.

(c) Red Lead shall conform to Federal Specification TT-R-191a (97) percent Grade for "Red Lead; Dry and Paste-in-Oil."

(d) Iron Oxide shall contain not less than 98 percent Fe_2O_3 and shall not contain any organic coloring matter.

(e) Diatomaceour Silica shall be an approved commercial grade.

(f) Zinc Yellow shall contain not less than 40 percent CrO_3. It

shall be a basic zinc potassium chromate, soluble in acetic acid, free from lead compounds, and containing no added zinc oxide, and shall be stable or non-reactive with the pigments and vehicles specified.

(g) Titanium Dioxide shall be similar and equal to either "Ti-Pure O" as manufactured by Krebs Pigment & Color Corporation or "Titanox NC" as manufactured by the Titanium Pigment Corporation.

13-10. THINNERS AND SOLVENTS.

(a) Mineral Spirits shall have the following properties:

Gravity	43-37 degrees Baume
Flash Point (Closed cup)	100 degrees F. Min.
Initial Boiling Point	300-310 degrees F.
End Point	405 degrees F. Max.
A.S.T.M. Copper Strip Test	Negative
Solvency (Kauri-Butanol)	41 cc(a) 77 degrees F. Min.

(b) Dipentine shall have the following properties:

	Maximum	Minimum
Specific Gravity at 15.5°C.	0.854	0.845
Refractive Index at 20°C.	1.477	1.472
Unpolymerized Residue (percent) ($38NH_2SO_4$)	2.5	

A.S.T.M. Distillation Range:

5% Distilling at	173 degrees C.
10% Distilling at	175 degrees C.
97% Distilling at	188 degrees C.
Color-Lovibond 500 Amber	3

Appearance: Clear and free from suspended matter.

(c) Toluol shall conform to U. S. Navy Department Specification 52T7 entitled "Toluene (Toluol)," except that it shall have a solvency (Kauri-Butanol Method) of not less than 100 cc. at 77 degrees F.

(d) Xylol shall conform to A.S.T.M. Specification D364-36 for "Industrial Xylene (Xylol) or 'Solvent Naphtha,'" except that it shall have a solvency (Kauri-Butanol Method) of not less than 93 cc. at 77 degrees F.

(e) Normal Butyl Alcohol (Butanol) shall conform to A.S.T.M. Specification D304-33 for "Butanol (Normal Butyl Alcohol)."

(f) Ethylene Glycol Monoethyl Ether shall conform to A.S.T.M. Specification D331-35 for "Ethylene Glycol Monoethyl Ether."

13-11. MISCELLANEOUS MATERIALS.

(a) Oil, Linseed JJJ-O-331 for "Oil; Linseed, Boiled," or JJJ-O-336, for "Oil; Linseed, Raw," as specified or required.

(b) Insulating Varnish, U. S. Navy Department Specification 52-V-13b, entitled "Varnish; Insulating, (for) Electrical Purposes."

(c) Creosote Paint for surface treatment of timber shall conform to Federal Specification TT-W-561a, entitled "Wood Preservative; Creosote (for) Brush and Spray Treatment."

(d) Ortho-Phosphoric Acid (H_3PO_4), shall be a commercially pure

product, in liquid form, containing not less than 75 percent H_3PO_4.

(e) Sodium Dichromate, ($Na_2Cr_2O_7$) shall be a commercially pure product in crystalline form containing not less than 85 percent $Na_2Cr_2O_7$.

(f) Sand shall be perfectly clean, dry, de-dusted, silica sand particles, graded so that not more than 5 percent will be retained on a No. 30 mesh sieve and not more than 5 percent will pass a No. 50 mesh sieve, and shall be obtained by a wet-washing process.

13-12. INSPECTION.

(a) Unless otherwise specifically authorized, inspection of all materials for the paints and chemical rust inhibitor and the manufacture thereof, will be made by a representative of the contracting officer. All samples of materials and of the finished processed products will be tested and analyzed for conformity with the specification by the Government. The inspector will collect for testing, samples of each of the materials to be used in the manufacturing processes and will then seal the material containers until test results from the samples indicate that the various materials conform to specifications. He will witness the breaking of the seals on the approved material containers and the compounding of the materials for the product being manufactured, will collect samples of the finished product for testing, and will witness the placing, sealing, and labeling of the finished product in containers for shipment. After the finished products have successfully passed the prescribed test, shipment of the sealed containers will be authorized.

(b) In the case of ready-mixed and packaged paints of standard manufacture, other than those specified by trade name, the contractor shall furnish a sample in the standard stock package, together with a certified copy of the complete chemical analysis, for test and approval by the contracting officer.

13-13. PAINT FOR MAINTENANCE.- To insure that paint used for maintenance after completion of the work shall match the original, the contractor shall furnish to the Government not less than one gallon and not more than ten gallons of each color used. The quantity of each color furnished shall be determined by the contracting officer from consideration of the severity of usage to which the surface on which it is applied is likely to be subjected.

13-14. PAINT OUTLINE.

(a) Metal work shall be treated and painted as outlined in the following paint outline. Items requiring painting that may not be specified or listed shall be painted as directed by the contracting officer.

PAINT OUTLINE

em o.	PARAGRAPH REFERENCE	SHOP SURFACE PREPARATION & PAINTING			FIELD SURFACE PREPARATION AND PAINTING				
		Sand Blast	Wire Brush and/or Flame Clean	Primer	Wire Brush and Wash with Mineral Spirits	Sand Blast & Inhib.	Primer	Two Finish Coats	Extra Finish Coat
		13-02(a)	13-02(a)	13-04	13-02(b)	13-02(b)	13-04	13-05	
-	Overhead Cranes, Gantry Cranes, & Fixed Hoists	No	Yes	Red Lead	Yes	No (c)	Red Lead	Enamel**	No
2	Service Gates, exposed portions of guides and sills	Yes	No	" "	No	Yes	" "	Gray Enamel	Gray Enamel
3	Service Gate Hoists	No	Yes	" "	Yes	No	" "	"	No
4	Intake Stop Logs	Yes	No	" "	No	Yes	" "	"	Gray Enamel
5	Draft Tube Stop Logs	Yes	No	" "	No	Yes	" "	"	"
6	Construction Stop Longs	No	Yes	" "	Yes	No	" "	"	No
7	Exposed portions of Ice Gate guides & sills	Yes	No	" "	No	Yes	" "	"	Gray Enamel
8	Exposed portion of Ice Gate stop log guides and sills	Yes	No	" "	No	Yes	" "	"	"
9	Trash Racks	No	Yes	" "	No	No	" "	"	No
10	Turbine Embedded parts, (Exposed)	Yes	No	" "	Yes	No	" "	"	Gray Enamel
11	Exposed portions of structural and misc. steel	No	Yes	" "	Yes	No	" "	"	No
12	Piping (Exposed)**	No	No	No	Yes	No	" "	"	No

* See paragraph (b) Section 13-05 for painting different colors.
** Color as directed by Contracting Officer.
Note: Copper bearing steel parts need not be sand-blasted.

13-15. PAYMENT for all paint and painting will be included in the contract price for the respective metals or items painted, and in the contract prices for the installation of equipment.

13-16. STORAGE. - The contractor shall store all paint materials and tools and do all mixing of paints only in areas directed by the contracting officer.

Only as much material as may be used during a reasonable time shall be mixed at one time and all other paints shall remain in their original containers with unbroken seals. Stores of mixed paints shall be protected at all times to prevent intrusion of dirt or foreign material.

Oily rags and waste, when not in use, shall at all times be kept in fireproof, metallic containers subject to the approval of the contracting officer, and large accumulations of such material shall not be allowed to remain on the work. Highly inflammable materials in daily use shall be kept in containers not exceeding one gallon capacity each, and they shall be stored outside the building when not in continual use.

SECTION XIV

MISCELLANEOUS ITEMS

14-01. TILE GAGES.-

(a) General. - Two tile gages for indicating the elevation of the water surface shall be constructed in recesses provided therefor in the masonry walls. They shall be accurately graduated in feet and tenths; supplemental drawings showing required markings and details of placement will be provided later. The tiles shall be soaked in clean water for not less than 24 hours immediately before placing. They shall be imbedded in white cement mortar, with sand content as directed by the contracting officer, completely filling the recess and all joints and air cells in the tiles. Horizontal joints shall be 1/8 inch and vertical joints 1/16 inch in width. All joints shall be neatly painted with neat white cement mortar. Upon completion the entire surface of the gage shall be thoroughly cleaned with a weak solution of muriatic acid.

(b) Materials. - Tile for Gages shall be 5 inch by 11-7/8 inch by 3-3/4 inch vitrified fire clay, ceramic glazed load bearing tile. Variation in face dimensions shall be not greater than 1/16 inch in length and 1/32 inch in width. Tile units shall be glossy white glazed on the face with corrugated sides and back. They shall produce a clear ringing sound when tapped with a metal hammer, and shall be free from chipping, spalls, blisters and hair cracks. Numbers and graduations in glossy black as required shall be accurately and permanently fused into the glazed face of the respective units.

(c) Payment. - Payment will be made at the contract price per linear foot for "Tile Gage," which price will include the gages constructed, secured in place, neatly finished and cleaned.

14-02 GLASS BLOCK.

(a) General. - The contractor shall furnish and install all glass block panels in exterior walls as shown on detail plans to be furnished at a later date, or as directed by the contracting officer.

(b) Material and Installation. - Glass block shall be hollow, partially evacuated units, similar and equal to the Pittsburgh Corning Corporations's "Reeded Argus" pattern, or Owen-Illinois Glass Company's No. 402, coated on the edges with a grit-bearing water and alkaline-resistant plastic material. The glass blocks shall be installed in accordance with the best standard practice and the manufacturer's recommendations. The materials to properly install the glass blocks shall be approved by the contracting officer and shall include all expansion joint strips, oakum packing, felts, shearlock bars, wall ties, wall anchors, caulking, asphalt emulsion, and any other materials necessary for a complete installation.

(c) Payment. - Payment for furnishing and installing glass block panels will be made at the contract unit price per square foot for "Glass Block," and shall include all work and materials necessary for the complete installation.

14-03 STORM DRAINS.

(a) General. - The work includes furnishing all material and equipment and performing all labor necessary to construct storm drains, in-

cluding all pipe, joints, outlet walls and aprons, and such other appurtenances as may be necessary to provide a storm water drainage system complete in every respect in accordance with the specifications and drawings.

(b) Trenches. - Trenches shall be excavated with sides approximately vertical and the sides shall be kept in place by bracing and sheeting as required. The bottom width of trench shall allow sufficient room to properly lay the pipe and make the joints. The material excavated shall be deposited at the sides of the trenches, far enough away to prevent slides. Excavated material not required for backfilling shall be removed and deposited elsewhere as directed by the contracting officer.

(c) Pipe. - Pipe for storm drains larger than 12 inches in diameter shall be reinforced concrete culvert pipe, standard strength, conforming to the requirements of American Society for Testing Materials, Designation C 76-40T, "Reinforced Concrete Culvert Pipe." Pipe 12 inches in diameter or smaller shall be vitrified clay sewer pipe conforming to the requirements of Federal Specification SS-P-361 for "Pipe; Clay, Sewer."

(d) Pipe Laying.

(1) Foundation.-The bottom of the trench shall be prepared in such a manner as to provide a firm bearing for the entire length of each pipe and for at least one-fourth of its circumference, at the time the pipe is laid. Should the trench be excavated below the grade of the bottom of the pipe, it shall be refilled with material acceptable to the contracting officer and tamped to provide firm support for the pipe, as specified above. Pipe shall be laid accurately to the established line and grade, starting at the lower end. Pipe shall be laid with the bells at the upper end and depressions shall be excavated to fit the bells.

(2) Placing. - Water shall not be allowed in the trench while pipe is being laid, and pumps shall be provided if necessary to maintain a dry condition. Pipe shall be clean when placed in the trench, and care shall be taken to see that the bells are free from earth or other foreign matter when pipes are joined. After the jute or hemp packing has been placed, as hereinafter specified, the pipe shall be moved into position, tested for grade and alignment, and backfilled sufficiently to maintain the true position.

(3) Concrete Cradle.- Where drain pipe passes under railroad tracks, or elsewhere as directed, concrete cradle shall be provided to support and strengthen the pipe. Concrete materials shall be as specified in Section V and the class of concrete shall be Class "B" as specified in the same section. The concrete cradle shall extend two feet beyond the ends of the railroad ties.

(4) Joints. - The bell and spigot ends of the pipe shall be thoroughly cleaned before making the joint. After the spigot end has been inserted in the bell, the joint shall be packed with jute or hemp and thoroughly calked with suitable calking tools so as to leave an annular space around the pipe in the bell, not less than 3/8 inch in thickness and 2 inches in depth, for filling with mortar. No mortar shall be placed in the joint until the jute or hemp packing has been placed in the next two joints, the pipes properly aligned and bedded, and the packing calked. After the above preparations have been made, the annular space in the joint shall be filled with portland cement mortar, well rammed in with a wooden calking tool, then overfilled and left with a smooth finished surface. The mortar shall be composed of one part of portland cement and one part of sand, with enough water

added to get the proper consistency. The work must be watertight, and leaks or defects discovered must be repaired. Any pipe which has been disturbed after being laid shall be taken up, the joints cleaned, and the pipe properly relaid at the contractor's expense.

(e) Backfilling. - Backfilling of trenches shall proceed as rapidly as the pipes are approved after laying. In backfilling, except as otherwise specified, the earth shall be tamped around the pipe and bells and to one foot above the top of the pipe. Stones shall be kept far enough away from the pipe to avoid transmitting concentrated loads. The remainder of the filling may be done with scrapers or by hand and tamped to the satisfaction of the contracting officer, and the backfill shall be mounded over the trench to one foot above ground level. Under railroad tracks and roadways, the backfill shall be placed by hand to the top of the trench and thoroughly tamped as the filling proceeds. No frozen material shall be used for backfilling in any trench.

(f) Outlets. - Outlet protection walls of concrete and aprons of concrete and large stone shall be constructed at the outlets of storm drains. These walls shall be standard culvert headwalls as shown on the plans and described in paragraph 15-12(a).

14-04 CATCH BASINS.

(a) General. - The work includes furnishing all material and equipment and performing all labor necessary to construct catch basin of concrete or brick, including furnishing and placing cast iron inlet frames and gratings, and other work or material necessary to complete the work in accordance with the specifications and drawings.

(b) Type and Material. - Catch basins shall be rectangular for shallow basins, and circular for deep basins, as shown on the drawings. Rectangular basins shall be constructed of poured concrete and circular basins shall be constructed either of brick, concrete blocks, or poured concrete, at the option of the contractor. Materials for concrete and mortar shall conform to the provisions of Section V. Concrete shall be Class B as specified in that section. Brick shall be of medium quality and conform to Federal Specification SS-B-656 "Brick; Building (common), Clay." Brick or block manholes shall be laid in portland cement mortar consisting of one part cement to two parts of sand.

(c) Inlet Frames and Gratings. - Inlet frames and gratings shall conform essentially to the details and dimensions shown on the drawings. The material shall be cast iron conforming to Federal Specification QQ-I-652 for "Iron; Gray, Casting." The total combined weight of one inlet frame and grating shall be not less than 450 pounds.

14-05 PAYMENT FOR STORM DRAINS AND CATCH BASINS.

(a) Pipe. - Measurement of pipe for payment will be made from center to center of catch basins. Payment for furnishing and installing storm drain pipe will be made at the contract unit price per linear foot for "Furnishing and Installing Storm Drain Pipe" for the applicable size, which contract unit price shall include the cost of excavations for trenches, except as noted below, bracing and sheeting, dewatering, furnishing and laying the pipe, making the joints, backfilling the trenches, and other work necessary for a complete and workmanlike job as specified. If the required depth of trench to the bottom of the pipe exceeds 7 feet, the additional excavation will be paid for at the contract unit price for "Excavation, Common".

(b) Concrete Cradle. - Payment for furnishing and placing concrete cradle for storm drain pipe under railroad tracks or elsewhere as directed will be made at the contract unit price per cubic yard for "Concrete Cradle for Storm Drain Pipe."

(c) Catch Basins. - Payment for catch basins complete, including excavation, backfill, inlet frames and grating, material and labor will be made at the respective contract unit prices each for "Catch Basins, Rectangular" or "Catch Basins, Circular."

(d) Outlets. - Payment for outlet protection walls and aprons complete, will be made at the contract unit price each for "Culvert Headwalls, Standard", (See also paragraph 15-12(b)).

SECTION XV

RAILROAD AND HIGHWAY.

15-01. GENERAL. -

(a) Permanent Railroad and Highway. - The contractor shall construct a permanent railroad and highway, extending from the working limits of Long Sault Dam to the abutment of the powerhouse on Barnhart Island, and from ends of railroad and highway built by others on the Canadian side to the powerhouse connections as shown on the drawings.

(b) Access to Site. - A permanent railroad and a permanent highway will be built by others on the Canadian side, extending from respective points on the existing Canadian National Railway and New York Central Railroad, and Kings Highway No. 2, then both crossing a bridge over Lock 19 on the Cornwall Canal, thence along the canal bank to the site. These facilities will be built prior to this contract, and may be used by other contractors. (See also paragraphs 1-14, 1-19, and 1-36)

(c) Use and Maintenance. -

(1) The contractor shall maintain in serviceable condition during the life of the contract the permanent railroad and permanent highway built by others and all permanent railroads and permanent highways built by him, to the satisfaction of the contracting officer.

(2) The permanent railroad and highway bridge over Lock 19 shall be maintained by the contractor, but The Department of Transport of Canada will operate the structure.

(3) The contractor for the construction of Long Sault Dam shall have the privilege of constructing a temporary railroad and highway at the site, (see also paragraph 1-36).

(4) No separate payment will be made for maintenance described in par. 15-01 (c) (1) and the cost thereof shall be included in other bid items.

(d) The following specifications (paragraphs 15-02 to 15-15 inclusive) apply only to the permanent railroad and highway construction included in this contract.

15-02. FORMATION OF ROADBEDS. -

(a) Alignment. - The center of roadbed for the permanent railroad and highway specified in paragraph 15-01, shall conform in alignment to that shown on the drawings.

(b) Grade Line. - The grade line on the alignment drawings for the railroad denotes top of rail. The grade line for the highway indicates the top of the finished roadway surface.

15-03. CLEARING AND GRUBBING. - Clearing and grubbing shall conform to paragraph 3-01, and no separate payment will be made.

15-04. EXCAVATION AND EMBANKMENT. -

(a) Excavation and embankment construction shall conform to

Sections III and IV. All embankment shall be Class II fill as specified in paragraph 4-04. Payment will be made at the respective contract unit prices for the various items of work required. (See paragraphs 3-07 (b) and 4-04 (i)).

(b) Slopes for Grading.

(1) Grading shall be to the slopes shown on the drawings or as otherwise directed by the contracting officer.

(2) Should unforseen conditions arise or materials of unexpected nature be encountered at any time after the excavation has been started, the contracting officer may require the steepening or flattening or benching of such slopes.

15-05. EXCAVATION BELOW GRADE. - Excavation for the highway roadbed shall be carried to a depth of 15 inches below the grade line. The roadbed shall then be moistened if deemed necessary by the contracting officer and compacted to final dimensions and grades in the manner and to the density required for Class II fill as specified in paragraph 4-04. The finished roadbed for the highway shall be formed by placing 9 inches of gravel as specified in paragraph 15-11. Excavation below grade will be paid for at the contract unit price for "Excavation, Common".

15-06. DISPOSAL OF EXCAVATED MATERIALS. - It is intended that all suitable materials excavated from railroad and highway excavation will be placed in roadway embankments except as provided in paragraph 15-07.

15-07. SPOIL AREAS. - Materials to be wasted shall be deposited in the designated spoil areas shown on the drawings or in such other areas as the contracting officer may designate. The low places in the designated spoil areas shall first be filled to a uniform grade as directed by the contracting officer and additional waste material shall then be deposited uniformly over the designated area. Upon completion of wasting operations the contractor shall dress the spoil area to a uniform grade, sloping away from the roadbed with no slopes steeper than four horizontal to one vertical (4:1), all to satisfaction of the contracting officer.

15-08. BORROW AREAS.

(a) Classification. - Borrow areas for the various classes of materials are as follows:

(1) Borrow, Unclassified. - Materials for required railroad and highway embankments, in excess of materials secured from roadway excavations and other required excavations, shall be secured from borrow areas adjacent to the roadway as designated on the drawings or as directed by the contracting officer. The selection of the materials from the borrow areas and the placing of the materials in the embankments shall be subject to the approval of the contracting officer.

(2) Gravel Borrow. - Bank run gravel for surfacing the roadbed for the railroad and for the highway shall be obtained from sources approved by the contracting officer. The general requirements and information in paragraph 1-16 shall apply to gravel for roadbeds.

(b) Slopes and Berms of Borrow Pits. - Side slopes of borrow pits will usually be four horizontal to one vertical (4:1). An undisturbed berm of not less than 25 feet shall be left between the toe of the slope of embankments and the edges of the borrow pits. An undisturbed berm of not less than 10 feet shall be left between the top of the outside slope of the borrow pit and the right-of-way line.

(c) Staking of Borrow Pits. - Excavation in borrow pits shall be performed so as to leave as uniform a section as practicable in order to permit ready and accurate measurement. The depth of excavation in borrow pits shall be as directed by the contracting officer and will be dependent upon the suitability of the materials encountered in each specific location.

(d) Drainage and Final Dressing of Borrow Pits. - Borrow pits shall be excavated to a uniform grade and properly sloped and ditched so as to drain to the edge away from the roadway and to the nearest water course. The slopes of borrow pits shall be carefully dressed to the required slope and the bottom dressed to a uniform grade.

15-09. DITCHES.

(a) Ditches shall be excavated on the uphill side and above all excavations where the original ground slopes toward the roadway, and elsewhere as indicated on the drawings or ordered by the contracting officer. Intercepting ditches shall also be constructed at the foot of all embankments where deemed necessary and to the waterway which is provided to take the drainage under the roadway. Where directed by the contracting officer intercepting ditches shall be excavated in advance of roadway excavation and embankment placing. Material excavated from intercepting ditches shall be placed on the downhill side of the ditch and shall be neatly formed and sloped to an embankment section as directed by the contracting officer.

(b) Payment. - Payment will be made at the contract unit price per cubic yard for "Excavation, Common". (See also paragraphs 3-07 (b) (1) and 15-04)

15-10. SUPERELEVATION. - The tops of embankments for railroads and highways constructed on curved alignment shall be elevated as directed by the contracting officer.

Highway widening shall be as indicated on the drawings.

15-11. GRAVEL FILL BASE.-

(a) Material for gravel fill bases where indicated on the drawings shall be run-of-bank sand and gravel passing a 4 inch mesh screen as approved by the contracting officer. Gravel containing an excess of clay, silt or other unsuitable materials as determined by the contracting officer shall not be used. Embankments shall be constructed to final dimensions and grades free from ruts and depressions prior to the placing of gravel. Placing and compaction of the gravel base shall be done in accordance with the specifications of the State of New York, Division of Highways, item 39 - "Foundation Course, Run-of-Bank Gravel".

(b) Payment. - Payment will be made at the contract unit price per cubic yard for "Gravel Fill Base", measured to the lines indicated on the drawings.

15-12. CULVERTS. -

(a) The contractor shall furnish all materials, labor and equipment required for installing corrugated iron drainage culverts conforming to the requirements of paragraph 6-06, as indicated on the drawings. The lengths of culverts shall be as directed by the contracting officer. Each culvert shall be provided with a standard culvert headwall at each end, unless otherwise directed by the contracting officer. The outlines and dimensions shall be as shown on the drawings. Concrete shall be Class B as specified in Section V.

(b) Payment. - Payment for furnishing and installing culverts will be made at the contract unit price per linear foot for "Pipe; Corrugated Iron," of the applicable diameter. Earthwork will be paid for as indicated in paragraph 15-04 (a). Payment for standard culvert headwalls, complete, will be made at the contract unit price each for "Culvert Headwalls, Standard," (see also paragraph 14-06 (d)), which price shall include furnishing and constructing forms, transporting materials, mixing and placing concrete, and furnishing and placing the stone apron. Cement and aggregate for the concrete will be furnished by the United States at the usual points of delivery for such material at the powerhouse site (see par. 1-10).

15-13. BALLAST FOR RAILROAD.

(a) Materials. - Crushed rock for ballast shall conform to the latest A.R. E. A. "Specifications for Stone Ballast". Under quality requirements of this specification the test limits under "Suggested Specification Limits" shall conform to the requirements of Classification C.

(b) Ballasting and Surfacing. - The Contractor shall furnish and spread ballast of the kind and quality specified, raise, line, surface and tamp the track to stakes set by the contracting officer, and finish the ballast surfaces accurately to the detailed section shown on the drawings to the satisfaction of the contracting officer.

(c) Measurement and Payment. - Ballast material accepted and placed as a part of this work will be measured in cubic yards within the section as shown on the plans, and no payment will be made for additional quantities required to provide for shrinkage and settlement into the roadbed, superelevation of outer rail on curves, for hand-car rests, road approaches and crossings, handcar houses, etc. Volume of ties lying within the ballast sections shall be deducted using nominal 7"x9" dimensions in computing quantities of ballast. Payment will be made at the contract unit price per cubic yard for "Ballast." This payment shall constitute full compensation to the contractor for all expense necessary to furnish and transport ballast material to the work and placing in full conformity with the Plans and Specifications.

15-14. TIES.

(a) Physical Requirements. - Cross ties shall be sawed or hewed ties, 8 feet long, and shall conform to Federal Specificat ion

MM-T-371 dated May 26, 1937 for "Ties, Wood; Cross and Switch", size No. 5, 7 inches thick by 9 inches wide on top. All ties shall be creosote treated in conformity with the latest Federal Specifications. Switch ties shall conform to the quality of the above specifications, and their lengths will be as shown on the plans.

(b) Placing. - All maintrack shall be laid with 18 cross ties per 33 foot rail, and side tracks with 16 cross ties per 33 foot rail. A proportionate number of ties shall be laid under shorter rail sections.

(c) Measurement and Payment. - Measurement for ties will be per cross tie, and payment for furnishing and installing will be made at the contract unit price each for "Cross Ties", and shall include switch ties and all treatment and expense necessary to furnish and place ties in accordance with the plans and specifications.

15-15. TRACK. -

(a) Materials. - The contractor shall furnish all rails, turnouts, and appurtances. Rails shall weigh 90 pounds per yard and rails and fittings shall conform to the requirements of paragraph 6-07. Turnouts shall be as shown on the drawings.

(b) Laying.-

(1) Rails shall be spiked with four spikes per tie on tangent track and spikes staggered in each tie plate. On curved track two additional spikes per tie will be required unless otherwise directed by the contracting officer and these spikes must be placed on the inside of each rail.

Spikes must be started vertically and squarely in spike holes of the tie plate and driven straight to full bearing on the base of the rail. Where spikes are withdrawn, the hole must be plugged, using a standard tie plug at the contractor's expense.

(2) Tracks must be laid to standard gage of four feet, eighth and one-half inches on tangents and on curves of six degrees or less. Gage should be widened one-sixteenth of an inch for each degree over 6 degrees to a maximum of four feet nine inches as directed in each case by the contracting officer. The alignment must be maintained on outside rail and the extra width of gage applied to inside rail. This extra width should be uniformly decreased on the spiral from the point of the circular curve to the point of tangent, or uniformly graduated in the first rail length of a simple curve.

(3) Alignment of tracks shall conform strictly to the center line stakes and the top of rail shall conform strictly to the grade stakes. Rails must be laid with broken joints in all tracks. In main track the joints on one side must not vary more than one foot in either direction from the midpoint of the opposite rail. Rails less than standard length shall be used for the inside rail on curves to bring the joints to their proper position. When laying up to the switches a combination of rails less than standard length must be used to avoid cutting if practicable.

(4) In laying rail the ends shall be properly spaced to allow for expansion as directed by the contracting officer and rails must be laid consecutively to line and gage, one at a time and full bolted before spiking. The practice of coupling up long stretches of rail and subsequently throwing to line will not be permitted.

(5) In cutting rail, a saw or chisel should be used. Use of torch will not be permitted in cutting rails or bolt holes. All necessary new bolt holes shall be drilled.

(6) Joints must be properly put on with the full number of bolts, nuts, spring washers and nuts screwed up tight. Bolts must be gone over and retightened at short intervals until all are tight. Bolts shall be placed with nuts alternately on the inside and outside of rails. Spikes should not be driven in the joint bar slots or at the ends of the joint bars where the spikes may interfere with free movement of the rails.

(7) When laying rails, care must be taken to avoid locating joints in road crossings, in handcar set-offs or on ends of bridges or trestles.

(8) Anti-creepers to prevent longitudinal movement of rail in track shall be installed as directed by the contracting officer.

(c) Measurement and Payment.-

(1) Measurement for track laying will be made along the centerline from the point of beginning to the point of ending.

(2) Payment for track laying shall include the furnishing of all rails and appurtenances and will be made at the contract unit price per track foot for "Track Laying".

15-16. SIGNS AND MARKERS. -

(a) All necessary signs and markers shown on the drawings or required by the contracting officer shall be installed conforming to the standards of the New York Central Railroad.

(b) Payment.- Payment for all signs and markers shall be included in the contract unit price for "Track Laying".

15-17. BITUMINOUS MACADAM ROAD SURFACING.-

(a) General.- On top of the 9 inch gravel base, (paragraph 15-11), the bottom course of the roadway surfacing shall be a 4 inch bituminous macadam penetration course, and the top course 2 inches plant mix bituminous macadam.

(b) Bottom Course.- The bottom course bituminous macadam shall be 4 inches thick after compaction and rolling. The materials, methods of work, surface testing, and other items shall conform to the specifications of the State of New York, Division of Highways, Item 45-S - Bottom Course Bituminous Macadam - Penetration Method. The asphalt shall conform to Item 64P-A and the amount used shall be two gallons per square yard or as ordered by the contracting officer.

(c) Top Course.- The top course bituminous macadam shall be 2 inches thick after compaction and rolling. The materials, method of work, surface testing, and other items shall conform to the specifications of the State of New York, Division of Highways, Item 53-Top Course Bituminous Macadam - Mixing Method, Type 3.

(d) Payment.- Payment for the bottom and top course of road surfacing will be made at the contract unit price per square yard for "Road Surfacing" which payment shall include all materials, plant, and labor necessary for completion of the roadway in accordance with the drawings.

15-18. HIGHWAY GUARD RAIL.

(a) General.- A two wire guard rail shall be installed on both sides of all embankments where the height from toe of slope to

edge of shoulder is greater than 3 feet and elsewhere as directed by the contracting officer. Posts shall be 8 inch diameter fir, sound and free from defects. All posts shall be pressure creosote treated for the full length in accordance with the requirements of Federal Specification TT-W-571a for "Wood-Preservative; Preservative-Treatment" as shown in Table I for empty-cell treatment of structural timber for the size and material indicated. Creosote shall conform to Federal Specification TT-W-566. All holes shall be drilled before creosoting. Wire rope shall conform to Federal Specification RR-R-571, amendment 4, dated January 1941, for "Rope, Wire", for Type III, 3 by 7, annealed steel, galvanized wire rope. Anchor rods, clamp bolts, and all metal parts and fittings shall be galvanized iron. The posts shall be set plumb, evenly spaced, and true to lines and grades as indicated on the drawings. The wire shall be put through hook bolts, or through posts as required, and shall be drawn taut and fastened securely on both ends as indicated. Where necessary, cable shall be neatly and carefully spliced or joined by means of metal sockets into which the cable's ends are securely fastened by pouring full of molten zinc. Deadman type anchors shall be provided at the ends, and at intervals of 600 feet as indicated on the drawings.

(b) Measurement and Payment.- Payment for furnishing and installing guard rail, complete, will be made at the contract unit price per lineal foot for "Highway Guard Rail." Measurement will be made from center to center of end posts plus an allowance of 15 feet for each anchorage.

15-19. SEEDING.- Seeding of any slopes as required by the contracting officer shall meet the requirements of paragraph 4-09.

SECTION XVI

GOVERNMENT FIELD OFFICE

16-01. GENERAL. - The contractor shall construct a tempory field office for use by the field force of the contracting officer, complete and ready for occupancy in accordance with the drawings and specifications. The contractor shall complete the field office to such extent as will permit occupancy within 30 calendar days after date of receipt of notice to proceed, and the entire building complete with all fixtures and installations shall be completed within 60 calendar days after receipt of notice to proceed. The building will be located at a site to be selected by the contracting officer after award of the contract. It is the intent of the Government to locate the building in the proximity of the contractor's office and shops at the site of the work. All materials specified shall conform in all respects to current Federal Specifications whenever applicable. All other materials shall be as specified or otherwise required by the contracting officer.

16-02. FEDERAL SPECIFICATIONS. - Applicable Federal Specifications for materials required for the field office are as follows:

FEDERAL SPECIFICATIONS

Material	Serial Number	Title
Galvanized Iron	QQ-1-696	Iron and Steel; Sheet, Black and Zinc-Coated (Galvanized).
Steel Pipe	WW-P-403a	Pipe; Steel and Ferrous-Alloy, Wrought, Iron-Pipe-Size
Glass	DD-G-451	Glass; Flat (for) Glazing Purposes
Lumber	MM-L-751b	Lumber and Timber; Softwood
Magnesia	HH-M-61	Magnesia; Block, Cement, and Pipe Covering (Molded)
Pipe - Soil	WW-P-401	Pipe and Pipe-Fittings; Soil, Cast-Iron
Pipe-Fittings	WW-P-501a	Pipe - Fittings; Cast-Iron (threaded)
" "	WW-P-521a	Pipe - Fittings; Malleable - Iron (threaded) 150 pounds
Roofing	SS-R-521	Roofing and Shingles; Asphalt Prepared, Mineral-Surfaced
Plumbing	WW-P-541a	Plumbing - Fixtures; (for) land use

Material	Serial Number	Title
Putty	TT-P-791a	Putting; Pure-Linseed Oil, (for) Wood-Sash Glazing
Venetian Blinds	LLL-B-441	Blinds; Venetian, Wood-Slat (Type I)
Sheathing Paper	UU-P-536	Paper; Sheathing, Waterproof
Wall Board	SS-W-51a & Amendment 1 dated October 1937	Wall-Board; Gypsum

16-03. EXCAVATION, FILLING AND GRADING

(a) The contractor shall make the necessary excavation for the parking lot area, foundation, footings, fuel tank, septic tank, pipings and drains as shown on the drawings. The contractor shall construct a parking space adjacent to the field office large enough to accommodate 15 automobiles; the area shall be graded, all rock or other obstructions removed, and the area covered with compacted bank run gravel to a minimum depth of 6 inches. The contractor shall provide suitable gravel surfaced driveways from the parking area to the contractor's access road; gravelled walkways necessary for access from office to parking area and roadways in the vicinity. All walkways shall be covered with 3 inches of rolled bank run gravel fill, built to line and grade as staked in the field.

(b) Furnace Room. - The foundation area covered by the furnace room shall be stripped to a depth sufficient to remove all vegetable matter, then refilled and tamped with pervious material as directed by the contracting officer, to a grade 4 inches below the floor grade as shown on the drawings.

16-04. FOUNDATION. - The foundation and footings shall be of Class "B" concrete, having 1-½ inch maximum size aggregate, in accordance with Section V of these specifications, constructed to line and grade as shown on the drawings. The foundation posts shall rest on the footings and after being set to exact line and grade shall be anchored into place by backfill thoroughly tamped in thin layers to the height of finished grade as shown on the drawings. The girders supported on top of the posts and foundation shall be securely anchored thereto by bolting as shown on the drawings. Bolts in the foundation shall be placed during concreting operations.

16-05. CONCRETE FLOORS. - The floor in the furnace room shall be of Class "A" concrete, in accordance with Section V of these specifications, 4 inches thick, trowelled level, smooth and to a straight edge, or as specified. The furnace room floor shall have floor drain and trap located as shown on drawings, set 1 inch below floor grade and the floor trowelled smooth and to a straight edge from the drain to floor grade at each side. Reinforcing for concrete floors shall be 4-inch by 12-inch welded wire fabric of No. 10 and No. 12 wire gage.

16-06. FRAMING. - Lumber for framing shall be equal to No. 2 common fir. It shall be thoroughly seasoned, straight, even sawed, square cornered, sound and free from defects which may impair its strength, durability or its usefulness, for the purpose intended. All lumber shall be of commercial sizes, surfaced four sides unless shown or specified otherwise. The framework shall be constructed as indicated on the drawings and shall be erected

in a substantial manner. Studding shall not be spaced over 16 inches on centers for exterior walls and not over 24 inches on centers for interior walls, doubled at all openings larger than the normal spacings and when cutting through joists or rafters, headers shall be provided to double the framing around the openings. Double studs shall be provided at all corners of the building. Knee braces shall be provided from the corner studs to the fifth stud, diagonally from bottom plate to top plates at all corners of the building. Ridge board shall be provided at the ridge of the roof. All spiking of assembled members of framing shall be clinched by not less than 1/4-inch. Rafters and ceiling joists shall be spaced at 24-inch centers or as shown on drawing.

16-07. FLOORS. - Subflooring shall be nominal 1"x6", 1"x8", or 1"x10" boards, S4S, laid diagonally with 1/16-inch joints between boards and nailed to each joist with two 10d nails for boards 6 inches wide or three 10d nails for boards wider than 6 inches. Nail heads shall be driven below the surface of the boards. Asphalt saturated felt weighing 15 pounds per 100 sq. ft. shall be laid on the subfloor. The finish floor shall be 5/8"x3" tongue-and-groove clear edge grain, kiln dried, B grade fir or equal, and shall be driven up tight, blind nailed, sanded, and oiled as specified in paragraph 16-19. All flooring shall be satisfactorily protected from dampness and the weather before being placed. Floor joists shall be spaced on 16-inch centers.

16-08. SIDING. - The outside faces of the building shall be covered with 25/32" asphalt-covered fibre sheathing similar and equal to Johns-Manville "Weathertite," nailed securely to every 2"x4" stud with 8d flat-headed wire nails. A layer of 15-pound asphalt-saturated felt shall be applied between the sheathing and the outside siding. The outside siding is to be asbestos-cement shingles similar and equal to Johns-Manville No. 109U, laid according to the manufacturer's recommendations.

A 20 gage corrugated galvanized iron flashing shall be run continuously along the sill of the building and buried at least 12 inches below the finished ground line. Counter flashing of 24 gage galvanized sheet iron shall be applied as shown on the drawings. All seams shall be soldered. The galvanizing shall be Class "D" - Ordinary Coating.

16-09. ROOFING. - Roof sheathing shall consist of 1-inch by 6-inch No. 2 fir or equal, matched and dressed on both sides with no beading. The roofing shall be double-coated strip shingle similar or equal to "Flintkote" roofing weighing not less than 210 pounds per square. The roofing shall be securely fastened with large headed, 3/4-inch galvanized roofing nails. All seams, nail holes and other breaks in the roofing shall be thoroughly sealed with an approved mastic roofing cement. The ridge shall be covered by a strip of roofing not less than 12 inches in width, bent over the ridge and securely sealed and nailed on each side. Galvanized iron flashing shall be provided and installed as shown on the drawings or as directed by the contracting officer.

16-10. WALLS AND CEILINGS.

(a) General. - With the exception of the bathroom and furnace room, the inside of all exterior walls, both sides of all interior walls and all ceilings shall be covered with 1/2-inch insulating board similar and equal to "Celotex" extending from floor to ceiling, securely fastened to all bearings. One-inch quarter round mouldings shall be provided at all corners. The edges of the insulation board shall be beveled at joints.

(b) Furnace Room. - The insulating board for walls and ceilings of furnace room shall be 3/8-inch gypsum board, applied and finished in accordance with subparagraph (a), above.

(c) Walls and Ceiling; Bathroom. - The ceiling shall be covered with ½-inch insulating board, similar and equal to "Celotex." The inside of the exterior wall and all interior walls shall have a covering of pressed wood ¼-inch thick similar to "Tempered Presdwood" manufactured by Masonite Corporation, extending 4'-0" above the floor. The exterior wall shall have ½-inch insulating board similar and equal to "Celotex" back of the pressed wood, and all walls above the pressed wood shall be covered with the same type of insulating board. Furring strips shall be used where required to make the finish surfaces of pressed wood and insulating board flush where they join each other, and the joint shall be covered with a moulding of 1-inch by 3-inch No. 2 fir or equal. The edges of the insulation board shall be beveled at joints. One-inch quarter round shall be placed at all vertical corners and in horizontal corners along the ceiling.

(d) Shower Stall. The contractor shall furnish and install a commercial shower stall, complete with fittings, as shown on the drawings, similar and equal to "Marine No. 15," manufactured by the Fiat Metal Manufacturing Company, Chicago, Illinois.

(e) Ceiling Insulation. · Between all ceiling joists and extending over wall plates, as shown on the drawings, a rock fiber or chemically treated wood pulp insulating material 4 inches nominal thickness shall be installed. Insuration shall weigh not more than 10 pounds per cubic foot.

16-11. EXTERIOR TRIM. - Exterior trim shall be equal to No. 2 fir finishing stock 3/4-inch thick except as otherwise noted. Door and window casings shall be 3/4-inch by 3-½ inches wide. All other exterior finish shall be to size as indicated on the drawings. Insulating wool of a quality satisfactory to the contracting officer shall be placed entirely around all window frames and around the jambs and heads of all door frames as shown on drawings.

16-12. INTERIOR WOOD FINISH. - All interior wood finish shall be equal to No. 2 fir finishing stock throughout, 3/4-inch or 13/16-inch thick and of sizes as indicated on the drawings. Water closet stalls shall be 6 feet - 4 inches high finished as shown on the drawings or as directed by the contracting officer. Over each lavatory a 16-inch by 24-½ inch mirror with white enamel metal frame shall be installed. Instrument cabinets shall be constructed as shown on drawing or as directed by the contracting officer.

16-13. WINDOWS AND FRAMES. - Windows shall be of stock pattern, No. 2 fir, or equal, double hung sash as shown on the drawings, glazed with clear glass. Windows in bathroom shall be single sash, hinged at bottom to open inward, glazed with clear glass, and fitted with cabinet latches. All frames shall be constructed so as to receive screens or storm windows, and as shown on the drawings. All glass will be as specified in paragraph 16-02.

16-14. DOORS AND FRAMES. - Exterior doors shall be solid construction, equal to No. 2 fir, 1-3/4 inches thick, designed as shown on the drawings. The upper part shall be of glass equal to that specified in paragraph 16-02, set in place with wooden stops on the inside and securely bradded and puttied outside. Interior doors, unless otherwise specified, shall be 1-3/8 inches thick, equal to No. 2 fir and shall have five cross panels. Standard stock doors of equal quality and size will be acceptable. Doors for water closets shall be 2'-0" x 4'-6" frames made up of 3/4" x 3-½" framing and covered with pressed wood 1/8-inch thick similar and equal to "Tempered Presdwood" manufactured by Masonite Corporation. Doors for the instrument cabinet shall be 1'-8" x 7'-8" as shown on drawings, made up of 1-1/8" x 3" framing and covered with pressed wood 1/8-inch thick.

The interior side of the furnace room door shall be covered with 28 gage galvanized iron as shown on the drawings.

16-15. SCREENS. - All windows and outside doors shall be equipped with screens. Window soreen frames shall be constructed of No. 2 fir or equal, 1-1/8 inches thick with 2-inch side and top rails and 3-½ inch bottom rails, divided at the center horizontally by a 2-inoh rail. Screen door frames shall be of same material and construction as specified for windows, but with two horizontal intermediate rails, one at 2-½ feet and one at 3.0 feet from bottom. Standard stock soreen doors of equal quality and size will be acceptable. All Specification RR-C-451a for "Cloth; Wire Soreen". Type "D", stretched and secured with suitable wood strips, well bradded. Suitable soreens shall be placed over the bathroom windows.

16-16. LOUVRES . - Wooden louvres shall be constructed and installed at both ends of the building as shown on the drawings. Removable screens and storm protection panels shall be furnished and installed in louvres, as shown on the drawings.

16-17. VENETIAN BLINDS. - All double hung windows, exoept in the furnace room, shall be fitted with venetian blinds with rust proof hardware fittings, automatic cord lock stopping devioe and spiral gear to tilt slats. The wooden slats shall be finished in ivory or oream color and the tape shall harmonize with the finish color of the wood. The blinds shall oonform to the requirements of Federal Specification LLL-B-441 for "Blinds; Venetian, Wood-Slat", (Type I).

16-18, HARDWARE. - The contractor shall furnish and install all hardware specified below. All hardware shall be accurately and securely installed. At completion, all keys shall be delivered, properly labeled, to the contracting officer. All hardware shall be of stock design with sanded brass finish, and shall be of the following types, as specified.

(a) Entranoe Doors.

2 sets -1½ prs. of 3-½" x 3-½" loose pin, butt hinges.
2 cylinder locks with 5-½" x 3-5/8" x 3/4" case.

(b) Interior Doors.

6 sets -1½ prs. of 3-½" x 3-½" loose pin, butt hinges.
6 Mortise locks with 3-5/8" x 3-7/8" case.

All locks shall be complete with two keys and approved knobs, latches and escutcheons.

(o) Windows.

100 Iron easy spring window bolts and fasteners.
2 prs. 1-½" x 1-½" tight pin, butt hinges.

(Bathroom windows.)

2 Cabinet latches. (Bathroom windows.)

(d) Water Closet Doors

2 latches and keepers.
2 prs. spring hinges (for 3/4-inch doors.)

(e) Instrument Cabinets.

4 night locks complete
4 prs. cabinet hinges (for 1-1/8 inch doors).

(f) Miscellaneous.

54 screen hangers complete
29 - 3-inch hooks and eyes.
2 prs. screen door hinges

The contractor shall furnish and install all other hardware and minor parts that may be necessary to complete the contract.

16-19. PAINTING.

(a) Exterior. - Before applying any paint the surface to be painted shall be thoroughly dry and free from dirt, oil, grease and other foreign substances. As soon as complete the outside surfaces, of windows, doors, and screen frames shall be given one priming coat of paint, conforming to Federal Specification TT-P-362 for "Paints; Lead-Zinc-Base, Ready-Mixed and Semipaste, White and Tinted". After the priming coat has thoroughly dried, one finishing coat of white outside house paint, shall be applied to all wood surfaces, except the outside trim. All outside trim surfaces shall be painted with one finishing coat of green, medium shade, outside paint as approved. All paint for finishing coats shall be of stock No. 6 B S-W ODP White Lead as manufactured by the Sherwin Williams Company, or equal.

(b) Interior. - All interior woodwork, except floors, shall be painted with two coats of inside paint of approved manufacture and color. All finished floors shall be given one heavy coat of boiled linseed oil.

16-20. PLUMBING.

(a) All labor and materials required for installing a complete plumbing system shall be provided as indicated on the drawings and in accordance with these specifications and in accordance with any State or local regulation, and the publication "Recommended Minimum Requirements for Plumbing in Dwellings and Similar Buildings", issued by the Bureau of Standards.

(b) The plumbing fixtures and accessories shall be similar and equal to those designated below, reference being made, for identification only, to catalog numbers as listed in Kohler Co. Catalog K-39.

2 Closets, No. Brooklands K-3940-PR complete with fittings.

2 Toilet paper holders.

2 Lavatories No. Clare K-3000-P with fittings.

1 Floor drain and trap.

1 - 3'-0" Urinal - Jarves No. K-5052-A complete with fittings.

(c) The field office shall be supplied with a constant and uninterrupted potable water supply of not less than 35 and not more than 50 pounds per square inch pressure, furnished by the contractor. The supply line shall

be 3-inch pipe placed in a trench of sufficient depth and protected to prevent freezing in subzero weather. At the point of entrance, in bathroom, a main shut-off and drain cock shall be installed. Pipe sizes and valves shall be as shown on the drawings. An automatic electric hot water heater of 30-gallon capacity shall be furnished and installed. The heater shall be similar and equal to Westinghouse Electric Manufacturing Company's Square Type Electric water heater, installed to manufacturer's specifications.

(d) The contractor shall lay a 4-inch vitrified pipe sewer line from the end of the cast iron soil pipe, outside the building to the sewage disposal tank located not less than 50 feet from the building. Vitrified pipe shall conform to the requirements of Federal Specification SS-P-361 for "Pipe; Clay, Sewer". The sewer shall be laid with ¼-inch to 1-foot pitch, true to line and grade, and made up with tight joints. The sewage disposal tank shall be similar and equal to Kaustine Standard Series Horizontal Septic Tank No. 85, and provided with proper connections for outlet and inlet pipes. The outlet shall connect to a grid system not to exceed 780 feet of 4-inch field tile pipe including connections. The joints of the field tile pipes shall be laid open, ¼-inch, and top half of each joint shall be covered with sheathing paper. If the field office is conveniently located, the sewer line from the Government Field Office may be connected to the sewer disposal system of the contractor's office, provided the system is designed to carry the extra sewage, subject to approval by the contracting officer.

16-21. ELECTRICAL WIRING. - The contractor shall secure all permits and give such notices as required by State and local authorities. The installation shall be in strict accordance with the National Electrical Code. The system shall be 3-wire, 220/110 volt, singlephase, solid neutral, rigid metal conduit to fuse cabinet as indicated on drawing. All wiring shall be rubber-insulated, non-metallic, sheathed cable, similar and equal to "Wire-flex" as manufactured by the Wiremold Company. The building shall be wired as indicated on the drawings. Three main feeders of not less than No. 8 AWG wire shall be installed in 1-inch conduit. The ground wire shall be not less than No. 8 AWG. The entrance switch shall be outside type, 3-wire, solid neutral, 2-pole, 30-amp. Fuse cabinet shall be flush type, steel with door and built for 6 circuits, with solid neutral, motor switch. The motor switch shall be of the automatic thermal protection, reset-type. Each circuit shall be fused with 15-amp. fuses. Duplex plug receptacles or convenience outlets shall be 15-amp., 125-volt, with stamped brass plates. At completion, all circuits shall be plainly marked for identification. The contractor shall furnish and erect in first class manner, all fixtures complete with shades and lamps of the wattage indicated, fuses and all other necessary accessories. The fixtures shall be similar and equal to those designated below. Reference is made, for identification only, to catalog numbers as listed in Benjamin Electric Mfg. Co., catalog entitled "Benjamin Sockets for Reflector Fixtures".

SCHEDULE

Location No.	No.	Type
Inspector's Office	2	5642 - PUL R.L.M. Dome with canopy and fixture stud.
Clerk's Office	1	5642 - PUL R.L.M. Dome with canopy and fixture stud.
Furnace Room	1	5423 Shallow Dome with canopy and fixture stud.

Location No.	No.	Type.
Bathroom	1	5423 Shallow Dome with canopy and fixture stud.
Bedroom	1	5642 - PUL R.L.M. Dome with canopy and fixture stud.
Field Engineers Office	1	5642 - PUL R.L.M. Dome with canopy and fixture stud.
Drafting Room	3	5642 - PUL R.L.M. Dome with canopy and fixture stud.
Platform	2	6821 Watertight angle with round box.

The contractor shall do all cutting and placing of supports necessary in this work.

16-22. HEATING.

(a) General. - The contractor shall furnish and install an oil burning automatic controlled furnace similar and equal to Mueller's No. 55 B. G. Fuel Oil Furnace. The installation and workmanship shall be in strict accordance with the specifications of the manufacturer, rules and regulations of the National Board of Fire Underwriters and local requirements.

(b) Grills, Registers and Ducts. - All grills and registers shall be furnished and installed by the contractor as shown on the drawings or as directed by the contracting officer. Warm air grills shall be provided with independently adjustable, manually controlled vertical fins for deflection of air. Cold air return register shall be plain lattice type, suitable for floor or wall installation and of the size indicated on the drawings. The hot and cold air duct, register and grill system shall be constructed in accordance with manufacturer's specifications, and installed as shown on the drawings or as directed by the contracting officer.

(c) Smoke Pipe and Vent. - The smoke pipe and vent shall be as specified by the manufacturer for furnace used. The smoke pipe from furnace to 2-inches above roof, shall be covered with asbestos air cell pipe covering, 1-inch thick, properly secured to the pipe.

(d) Fuel Tank.- A fuel supply tank of 500 gallons capacity shall be furnished and installed by the contractor. The tank shall be under ground and covered with not less than 2 feet of well tamped backfill. Fuel tank and all piping shall meet all requirements of the National Board of Fire Underwriters.

16-23. FIRE PROTECTION. - The contractor shall furnish and install one frost proof fire hydrant with suitable connections for two 1-1/2 inch fire hoses. The fire hydrant shall be installed not more than 25 feet from the building and shall be supplied with water at a pressure not less than 35 pounds.

16-24. FLAGPOLE. - The contractor shall furnish and erect one flagpole complete with pulley and rope, as shown on drawings. The flagpole shall be constructed of one 12-foot length of 2-1/2 inch and one 12-foot length of 2-inch galvanized steel pipe, with an overlap of 1 foot at joint, securely welded. The flagpole shall be securely fastened to a concrete base as shown on drawings and shall be so attached that bottom bolt can be removed and pole revolved about upper bolt to a horizontal position or as directed by the contracting officer.

16-25. REMOVAL OF BUILDING. - Upon completion and acceptance, the field office will become the property of the United States and will be removed by the Government. No materials or equipment shall be salvaged by the contractor.

16-26. PAYMENT. - Payment for the field office complete, including the furnishing of all labor, plant and materials necessary to complete the building in accordance with these specifications and as shown on the drawings, and including parking area, driveways, walks, and grading around the building, will be made at the contract lump sum price for "Field Office" upon acceptance of the building by the contracting officer. The contracting officer retains the right to order the contractor to make an extension as indicated on the drawings, with similar construction and equipment as the original building. Payment for the extension, if any, will be made at the lump sum price for "Field Office Extension".

Invitation No.

STANDARD GOVERNMENT FORM OF BID
(construction contract)

_____

(Place) _____

(Date) _____

To: The District Engineer,
U. S. Engineer Office,
Massena, New York.

1. In compliance with your invitation for bids dated _____ _____and subject to all the conditions thereof, the undersigned,

_____

a corporation organized and existing under the laws of the State of

_____

a partnership consisting of _____

_____

_____

or an individual trading as _____

_____

of the city of _____

hereby proposes to furnish all plant, labor, and materials and perform all work required for the construction of the Barnhart Island Power House, complete, at the locations shown and to the extent indicated, in strict accordance with the specifications, schedules, and drawings, for the consideration of the following prices:

POWERHOUSE

SCHEDULE OF BID ITEMS

Item No.	Designation	Unit	Quantity	Unit Price	Amount
1.	Timber Cribs	M.B.M.	2,100	$____	$____
2.	Crib Sheating	Sq.Ft.	28,000	$____	$____
3.	Steel Sheet Piling	Sq.Ft.	27,500	$____	$____
4.	Crib Fill	Cu.Yd.	48,000	$____	$____
5.	Earth Fill; Compacted Class I, Cofferdam	Cu.Yd.	46,000	$____	$____
6.	Earth Fill; Compacted Class II Cofferdam	Cu.Yd.	645,000	$____	$____
7.	Earth Fill; Class III, Cofferdam	Cu.Yd.	185,000	$____	$____
8.	Rock Fill; Cofferdam	Cu.Yd.	135,000	$____	$____
9.	Riprap; Cofferdam	Cu.Yd.	49,200	$____	$____
10.	Unwatering Cofferdams	Ac.Ft.	90,000	$____	$____
11.	Cofferdam Removal	Cu.Yd.	776,300	$____	$____
12.	Excavation; Common	Cu.Yd.	3,821,000	$____	$____
13.	Excavation; Rock	Cu.Yd.	225,000	$____	$____
14.	Line Drilling	Sq.Ft.	40,000	$____	$____
15.	Excavation; Borrow	Cu.Yd.	250,000	$____	$____
16.	Drilling Exploratory Holes 0 to 30 ft.	Lin.Ft.	1,250	$____	$____
17.	Drilling Exploratory Holes 30 to 60 Ft.	Lin.Ft.	1,350	$____	$____
18.	Drilling Exploratory Holes, 60 ft. and over	Lin.Ft.	2,500	$____	$____
19.	Drilling Grout Holes in Rock 0 to 30 ft.	Lin.Ft.	3,750	$____	$____
20.	Drilling Grout Holes In Rock 30 to 60 ft.	Lin.Ft.	7,800	$____	$____
21.	Drilling Grout Holes in Rock 60 ft. and over	Lin.Ft.	4,250	$____	$____

POWERHOUSE

SCHEDULE OF BID ITEMS

Item No.	Designation	Unit	Quantity	Unit Price	Amount
22.	Drilling Grout Holes in Concrete	Lin.Ft.	2,000	$____	$____
23.	Drilling 6 inch Drain Holes	Lin. Ft.	15,000	$____	$____
24.	Drilling 6 inch Concrete Cores	Lin.Ft.	1,000	$____	$____
25.	Core Boxes	Each	1,800	$____	$____
26.	Grout Pipes and Connection	Lb.	125,000	$____	$____
27.	Pipe; Black Steel, 8" Diameter	Lb.	53,000	$____	$____
28.	Pressure Grouting	Cu.Ft.	50,000	$____	$____
29.	Sand in Grout	Cu.Ft.	2,500	$____	$____
30.	Rock Flour in Grout	Cu.Ft.	3,000	$____	$____
31.	Earth Fill; Compacted Class I.	Cu.Yd.	1,580,000	$____	$____
32.	Earth Fill; Compacted Class II	Cu.Yd.	103,000	$____	$____
33.	Additional Compaction	Square	250,000	$____	$____
34.	Earth Fill; Class III	Cu.Yd.	250,000	$____	$____
35.	Rock Fill	Cu.Yd.	151,000	$____	$____
36.	Riprap; Dumped, Class A	Cu.Yd.	75,000	$____	$____
37.	Riprap; Dumped, Class B	Cu.Yd.	90,000	$____	$____
38.	Sand and Gravel Backing	Cu.Yd.	58,600	$____	$____
39.	Filter	Cu.Yd.	101,300	$____	$____
40.	Seeding	Acre	15	$____	$____
41.	Concrete, Class A	Cu.Yd.	134,000	$____	$____
42.	Concrete, Class B	Cu.Yd.	281,000	$____	$____
43.	Concrete, Class C	Cu.Yd.	1,503,000	$____	$____
44.	Straight Concrete Forms	Sq.Ft.	7,100,000	$____	$____
45.	Concrete Forms Curved One Way	Sq.Ft.	446,000	$____	$____
46.	Concrete Forms Curved Two Ways	Sq.Ft.	460,000	$____	$____

POWERHOUSE

Item No.	Designation	Unit	Quantity	Unit Price	Amount
47.	Absorptive Form Lining	Sq.Ft.	2,200,000	$_____	$_____
48.	Concrete Forms For Ceiling	Sq.Ft.	600,000	$_____	$_____
49.	Concrete Forms For Construction Joints	Sq.Ft.	3,820,000	$_____	$_____
50.	Monolithic Concrete Floor Finish	Sq.Ft.	160,000	$_____	$_____
51.	Reinforcing Steel	Lb.	108,000,000	$_____	$_____
52.	Drilling Holes For, and Placing Dowel Bars	Lin.Ft.	1,000	$_____	$_____
53.	Metal Reglets	Lin.Ft.	17,000	$_____	$_____
54.	Membrane Waterproofing	Square	1,250	$_____	$_____
55.	Copper Metal Work	Lb.	80,000	$_____	$_____
56.	Copper Water Stops	Lb.	40,000	$_____	$_____
57.	Lead Sleeves and Flanges	Lb.	15,000	$_____	$_____
58.	Sheet Iron and Steel	Lb.	65,000	$_____	$_____
59.	Special Bituminous Filler, Type C	Cu.Ft.	3,500	$_____	$_____
60.	Halved Concrete Pipe	Lin.Ft.	11,000	$_____	$_____
61.	Poured Grout	Cu.Ft.	115,000	$_____	$_____
62.	Special Non-shrink Grout	Cu.Ft.	1,000	$_____	$_____
63.	Structural Steel	Lb.	19,000,000	$_____	$_____
64.	Steel Track Rails	Lb.	2,720,000	$_____	$_____
65.	Miscellaneous Black Steel and Metal Work	Lb.	430,000	$_____	$_____
66.	Miscellaneous Galvanized Steel and Metal Work	Lb.	600,000	$_____	$_____
67.	Plain Gratings	Lb.	360,000	$_____	$_____
68.	Galvanized Gratings	Lb.	320,000	$_____	$_____
69.	Safety Treads and Thresholds	Lb.	110,000	$_____	$_____
70.	Cast Iron Frames & Covers	Lb.	40,000	$_____	$_____

POWERHOUSE

Item No.	Designation	Unit	Quantity	Unit Price	Amount
71.	Forgings, Steel	Lb.	2,000	$____	$____
72.	Bronze	Lb.	3,000	$____	$____
73.	Miscellaneous Non-ferrous Metals	Lb.	2,000	$____	$____
74.	Pipe Handrail	Lb.	70,000	$____	$____
75.	Concuit and Fittings	Lb.	1,225,000	$____	$____
76.	Outlet Boxes	Lb.	25,000	$____	$____
77.	Turbine Embedded Parts, Installation	Ton	5,500	$____	$____
78.	Installing Guides, Sills and Embedded Parts	Ton	1,664	$____	$____
79.	Installing Gates, Stop Logs, Racks and Gate Hoists	Ton	14,496	$____	$____
80.	Installing Cantry Cranes	Ton	200	$____	$____
81.	Installing Overhead Cranes	Ton	1,520	$____	$____
82.	Steel Pipe and Fittings, Black	Lb.	570,000	$____	$____
83.	Steel Pipe and Fittings, Galvanized	Lb.	750,000	$____	$____
84.	Wrought Iron Pipe and Fittings	Lb.	27,500	$____	$____
85.	Pickled Wrought Iron Pipe and Fittings	Lb.	500	$____	$____
86.	Cast Iron Pipe and Fittings	Lb.	1,500,000	$____	$____
87.	Duriron Pipe and Fittings	Lb.	500	$____	$____
88.	Forged Steel Fittings	Lb.	1,000	$____	$____
89.	Coating Underground Pipe and Fittings	Lb.	4,000	$____	$____
90.	Brass Pipe Fittings	Lb.	12,600	$____	$____
91.	Copper Tubing and Fittings	Lb.	100	$____	$____
92.	Inserts, Pipe Hangers and Supports	Lb.	500	$____	$____

POWERHOUSE

Item No.	Designation	Unit	Quantity	Unit Price	Amount
93.	Brass Valves	Lb.	500	$____	$____
94.	Iron-body Valves, Brass or Bronze Mounted	Lb.	67,500	$____	$____
95.	Roof Drains	Lb.	7,100	$____	$____
96.	Floor and Deck Drains, Brass or Bronze Strainers	Lb.	6,000	$____	$____
97.	Floor and Trench Drains, All Cast Iron	Lb.	6,000	$____	$____
98.	Precast Concrete Roof Slabs	Square	1,400	$____	$____
99.	Precast Concrete Roofing Tile	Square	2,900	$____	$____
100.	Built-up Asphalt Roofing	Square	1,400	$____	$____
101.	Lead Collar for 4-inch Toilet Vent	Each	10	$____	$____
102.	Tile Gage	Lin.Ft	70	$____	$____
103.	Glass Block	Sq.Ft.	20,500	$____	$____
104.	Storm Drain Pipe, 10-in.	Lin.Ft	525	$____	$____
105	Storm Drain Pipe, 12-in.	Lin.Ft	525	$____	$____
106.	Storm Drain Pipe, 18-in.	Lin.Ft	400	$____	$____
107.	Storm Drain Pipe, 24-in.	Lin.Ft	950	$____	$____
108.	Concrete Cradle for Storm Drain Pipe	Cu.Yd.	30	$____	$____
109.	Catch Basins, Rectuangular	Each	19	$____	$____
110.	Catch Basin, Circular	Each	6	$____	$____
111.	Culvert Head Walls, Standard	Each	28	$____	$____
112.	Pipes Corrugated Iron, 12-inch Diameter	Lin.Ft.	800	$____	$____
113.	Pipe; Corrugated Iron, 24-inch Diameter	Lin.Ft	268	$____	$____

POWERHOUSE

Item No.	Designation	Unit	Quantity	Unit Price	Amount
114.	Pipe; Corrugated Iron, 30-inch Diameter	Lin.Ft.	254	$____	$____
115.	Gravel Fill Base	Cu.Yd.	7,230	$____	$____
116.	Ballast	Cu.Yd.	6,200	$____	$____
117.	Cross Ties	Each	7,240	$____	$____
118.	Track Laying	Track Ft.	16,185	$____	$____
119.	Road Surfacing	Sq.Yd.	29,000	$____	$____
120.	Highway Guard Rail	Lin.Ft.	7,460	$____	$____
121.	Field Office	Sum	Job	$____	$____
122.	Field Office Extension	Sum	Job	$____	$____

NOTES: (a) All amounts and totals given above will be subject to verification by the United States. In case of variation between unit bid price and totals shown by bidder, the unit price will be considered to be his bid.

(b) All bids must be for the entire work and must have each blank space filled in.

(c) The quantities of each item of the bid, as finally ascertained at the close of the contract, in the units given and the unit prices of the several items stated by the bidder in the accepted bid, will determine the total payments to accrue under the contract. The unit price bid for each item must allow for all collateral or indirect cost connected with it.

2. EXPERIENCE. (See Invitation for Bids, paragraph 14.)

3. STATEMENT ESTABLISHING PERMANENT PLACE OF BUSINESS AND FINANCIAL STATUS. (See Invitation for Bids)

4. PLANT TO BE USED ON THE WORK. (See Invitation for Bids and paragraph 1-19 of the specifications.)

(a) Earth work.

(1) Excavating Equipment

No.	Type	Manufacturer	Capacity	Age	Condition

(2) Transporting Equipment.

No.	Type	Manufacturer	Capacity	Age	Condition

(3) Embankment Equipment.

(a) Spreading and Rolling Equipment.

(b) Pumping and Watering Equipment.

(b) Concrete.

(1) Batching Equipment

No.	Type	Manufacturer	Capacity	Age	Condition

(2) Transporting Equipment.

(3) Miscellaneous Equipment

(c) Drilling Equipment

No.	Type	Manufacturer	Capacity	Age	Condition

No.	Type	Manufacturer	Capacity	Age	Condition

(d) Grouting Equipment.

(e) Compressed Air Equipment.

(f) Pumping Equipment.

No	Type	Manufacturer	Capacity	Age	Condition

(g) Miscellaneous Equipment.

_____

_____

_____

_____

_____

_____

_____

5. PLANT LAY-OUT (See Invitation for Bids). - The undersigned has attached herewith the plant lay-out prescribed in the Invitation for Bids.

6. PROGRESS CHARTS (See Invitation for Bids). The undersigned has attached herewith the progress charts prescribed in the Invitation for Bids.

7. It is hereby warranted that in the event award is made to the undersigned there will be used in the performance of the work covered by the contract only such unmanufactured articles, materials, and supplies as have been mined or produced in the United States, and only such manufactured articles, materials, and supplies as have been manufactured in the United States substantially all from articles, materials, or supplies mined, produced, or manufactured, as the case may be, in the United States except as noted below or otherwise indicated in this bid or authorized in the specifications.

8. The undersigned agrees, upon receipt of written notice of the acceptance of this bid within _____ days after the date of opening of the bids, to execute the standard form of Government contract, in accordance with the bid as accepted, and give performance and payment bonds, with good and sufficient surety or sureties, for the faithful performance of the contract, and for the protection of all persons supplying labor and materials in the prosecution of the work, within _____ days after the prescribed forms are presented for signature.

9. The undersigned agrees to begin the work within _____ calendar days after date of receipt of notice to proceed, and complete it within _____ calendar days after date of receipt of said notice to proceed.

_____
(Bidder)

By _____
(Name and Title)

NOTE: Read Standard Government Instructions to Bidders before preparing this bid.

PART TWO

BARNHART ISLAND POWERHOUSE

SPECIFICATIONS
FOR TURBINES AND GOVERNORS

Specifications

For

TURBINES AND GOVERNORS

****

ST. LAWRENCE POWER DEVELOPMENT

Harza Engineering Co.
205 West Wacker Drive
Chicago, Illinois

December 29, 1941

WAR DEPARTMENT
ST. LAWRENCE RIVER DISTRICT

SPECIFICATIONS FOR TURBINES AND GOVERNORS

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WAR DEPARTMENT
St. Lawrence River District
U. S. Engineer Office
Massena, N.Y.

SPECIFICATIONS FOR TURBINES AND GOVERNORS

SECTION I - GENERAL PROVISIONS

1-01. LOCATION.

The Barnhart Island power house is located at the lower end of the International Rapids Section of the St. Lawrence River, about 8 miles north of the village of Massena, New York and 4 miles west of Cornwall, Canada. The site may be reached by U. S. Highways on the U. S. side of the St. Lawrence River and by Highway No. 2 on the Canadian side.

1-02. WORK TO BE DONE.

The work provided for under these specifications is authorized by _____ Act, approved _____ _____,1941.

The work consists of furnishing all plant, superintendence, technical services, labor and materials, except as hereinafter specified, and performing all work required for the design, manufacture, and furnishing and delivering f.o.b. railroad cars at factory shipping points, the hydraulic turbines and governor equipment, complete with accessories, for the Barnhart Island power house, all in accordance with the detailed requirements of these specifications and the following schedules:

Schedule A - Six (6)	67,100 hp turbines
Schedule B - Six (6)	67,100 hp turbines
Schedule C - Six (6)	67,100 hp turbines
Schedule D. -one (1)	9,000 hp turbine (house unit)

1-03. SHIPMENT. Material and machinery shall be furnished and delivered f.o.b. railroad cars factory shipping point and will be shipped on Government bills of lading furnished by the contracting officer. The contractor shall prepare all materials and articles for shipment in such manner as to protect them from damage in transit, and shall be responsible for and make good any and all damage due to improper preparation or loading for shipment. Where necessary, heavy parts or machines shall be mounted on skids or crated, and any articles or materials that might otherwise be lost shall be boxed or wired in bundles and plainly marked for indentification. All material shall be so loaded that it will not shift or become damaged during hauling. All parts exceeding 200 pounds gross weight shall be prepared for shipment so that slings for handling by crane from the car in the power house may be readily attached while the parts are on the car. Boxed parts, where it is unsafe to attach slings to the box, shall be packed with slings attached to the part, the slings to project through the box or crates so that attachment to the hoisting equipment can be readily made.

As soon as each shipment is made, the contractor shall furnish

shipping notices on which shall be shown, in addition to the usual data, a description of the article furnished and the item number of the contract schedule to which the article applies; also the shipping weight of each item. The total shipping weight shown on the shipping notice shall correspond to the total weight shown on the bill of lading.

It is understood and agreed that, if the actual shipping weight as later determined by the freight bills, exceeds the shipping weight stated by the bidder in his bid, the Government will deduct from any payment due the contractor the cost of transportation from the shipping point to Massena, New York, on such excess weight. Excess weight shall be defined as that in excess of the estimated weight given by the bidder in his bid. Where shipments are in fact made from points other than those stipulated in the contract or, at the option of the contracting officer, where excess weight is involved, an amount sufficient to cover any excess in freight costs to the Government will be withheld from final payment and vouchered to the General Accounting Office for direct settlement.

1-04. DRAWINGS. The following drawings, showing the general location, arrangement and dimensions of the power plant, accompany and form a part of the specifications. Additional drawings of the power plant are filed in the United States Engineer Office, St. Lawrence River District, Massena, New York, where copies may be obtained by interested parties:

Title	File Mark
Transverse Section Through Main (67,100 hp) Unit	48C11
Transverse Section Through House (9,000 hp) Unit	48C15
Plans at C. L. Distributor	48C35
Plans at Elev. 132 Floor	48C25

1-05. CONTRACTOR'S DRAWINGS.

The contractor shall, within 60 calendar days after receipt of notice to proceed with the work, submit for the approval of the contracting officer, outline drawings of all apparatus to be furnished under the contract, together with weights of equipment and overall dimensions, to enable the contracting officer to proceed with the final designs of the turbine foundation and power house. These drawings shall cover draft tube liner, speed ring, discharge ring, pit liner and servomotor location, piping layout and layout of equipment with necessary electrical controls for the main turbines and the house turbines and also the scroll case for the house turbine. Should any changes in these drawings be required as a result of the model tests specified in paragraph 2-04, prints of revised drawings shall be furnished as soon as practicable after completion of the model tests.

The contractor shall submit for approval sectional drawings of the complete turbine including a vertical section through the unit, a horizontal plan section at the top of the scroll case and servo-motors, and such additional assembly and sub-assembly and detailed drawings as are required to fully demonstrate that all parts of the apparatus to be furnished will conform with the provisions and intent of the specifications.

To facilitate approval of drawings, two prints with the original carrying letter and a copy thereof shall be submitted to the contracting officer, and two prints with a copy of the carrying letter shall be forwarded to

(Details of routing of prints of shop drawings to be inserted by U. S. Engineer office)

Decision on these drawings, either approval or disapproval, will be given by the contracting officer by letter or telegram within fifteen calendar days after receipt of drawings by the contracting officer. In the event that action on drawings is not taken within fifteen calendar days, the time for completion of the contract will be extended as provided in paragraph 1-06. The same number of copies shall be re-submitted in the same way for approval for any drawing returned by the contracting officer for correction.

After final approval of any drawing, six additional prints of that drawing shall be forwarded to the contracting officer.

All drawings submitted for approval, except the contractor's standard drawings or detail sheets, shall be on sheets of the standard dimensions of the United States engineer Department (27" x 42" overall with 2" trim margin on the left side and 1/2" trim margin on the other sides.) Each shall be provided with a blank white space, approximately 3 by 4 inches, near the lower right corrner specifically indicated to be used for notations by the contracting officer. All of these drawings will form a part of the contract. All of the applicable requirements of this paragraph with reference to drawings to be prepared by the contractor shall apply equally to catalog cuts, illustrations, printed specifications or other data submitted for approval, except that where specifically indicated in the detailed specifications that a smaller number than twelve (total) will meet the requirements of the Government, such lesser number may be furnished.

Any construction work done prior to the approval of drawings will be at the contractor's risk. The contracting officer shall have the right to require the contractor to make any changes in the designs which in his opinion are necessary to make the apparatus conform to the provisions and intent of these specifications, without additional cost to the Government. Approval by the contracting officer of the contractor's drawings shall not be held to relieve the contractor of any part of the contractor's obligation to meet all of the requirements of these specifications or of the responsibility for the correctness of the contractor's drawings. Upon complet on of the work under this contract, the contractor shall furnish a complete set of process tracings together with two conplete sets of blue-prints of all drawings, as finally approved, and four copies of operating instructons and parts catalogs. These tracings and drawings shall show all changes and revisions made up to the time that the apparatus is completed and accepted.

Parts catalogs and operating instructions, expecially prepared covering all equipment furnished under this contract, the turbines and governing equipment separately, which may be needed or useful in operation, maintenance, repairs, dis-assembly or reassembly, and for repair and identification of parts for ordering replacements, shall be assembled under a suitable common cover.

1-06. COMMENCEMENT, PROSECUTION AND COMPLETION.

The contractor shall commence work under the contract within ten (10) calendar days after the date of receipt by him of notice to proceed, prosecute the said work with faithfulness and energy and complete the entire work specified within the peroids of time (calendar days) stated in Table I, after said date of receipt of notice to proceed.

If the contractor furnishes turbines and governors under more than one schedule, the work under separate schedules shall be executed by him concurrently and no additional time will be allowed for delivery because of said combined contract.

TABLE I - SCHEDULE OF DELIVERIES

	MAIN UNITS (67,100HP)					
SCHEDULE A	NO.36	NO.35	NO.30	NO.29	NO.24	NO.23
SCHEDULE B	NO.34	No.33	NO.28	NO.27	NO.22	NO.21
SCHEDULE C	NO.32	NO.31	NO.26	NO.25	No. 20	NO.19
SCHEDULE D	HOUSE UNIT (9,000 HP)					

ITEM	PERIOD	Days	Days	Days	Days	Days	Days	Days
Design and construction and test, of first model test turbine with scroll case and draft tube (see par. 2-04) but not including final detail drawings		120	-	-	-	-	-	-
Delivery of draft tube liner, f.o.b. shipping point		400	420	440	460	480	500	500
Delivery of set of embedded parts including throat ring, speed ring and pit liner, f.o.b. shipping point. . . .		500	530	560	590	620	650	650
Delivery of complete turbine, f.o.b. shipping point.		800	850	900	950	1000	1050	700
Delivery of complete governor, f.o.b. shipping point.		840	900	960	1020	1080	1160	750

In the event that more than one model test (the original, or first, model test) is required by the contracting officer, the time for completion of all succeeding phases of the work for the applicable turbines, except the governors, will be extended as follows:

For each model test the actual number of days required therefor but not to exceed 90 calendar days for a complete re-design of the model nor more than 20 calendar days for minor changes of the model.

In the event that decision on approval of drawings is not given by the contracting officer within the 15 calendar day period allowed in paragraph 1-05 hereof, the time for completion of the contract will be extended in an amount equal to the excess time required for such action.

1-07. SUNDAYS AND HOLIDAYS

No work shall be done on Sundays or on days declared by Congress as holidays for per diem employees of the United States except in case of emergency, and then only with the written consent of the contracting officer.

1-08. PAYMENTS.

Subject to all the provisions set forth below, payments to the contractor will be made monthly or at such other times as may be mutually agreeable to the contractor and the contracting officer on estimates of such work as has been accomplished in accordance with the specifications and not included in any prior estimate. Estimates for items for which the units are "man days" will be based on the actual quantities of work performed, expressed in such units. Estimates for all other items will be based on a well balanced schedule prepared by the contractor and approved by the contracting officer, apportioning the contract prices of the respective items to the principal features entering into or forming parts of said items. The amount apportioned to each of said principal features shall be separately stated for labor and material, and the total amount shown by the schedule for any item shall equal the contract price for said item. Payments will be subject to retained percentages as provided in Article 16 (b) of the contract. Payment of the amount so retained will be made upon final and complete delivery of all material f.o.b. railroad cars at factory shipping points, EXCEPT that an amount equal to five (5) per cent of the total contract price will be withheld until after 100 days of actual satisfactory operation of equipment and the passing of tests as specified in paragraphs 2-05 and 2-06, but not more than 3 years after completion and offer of shipment, when final payment will be made.

1-09. INSURANCE.

1-10. INTERPRETATION OF SPECIFICATIONS.

1-11. MATERIALS AND WORKMANSHIP

1-12. WORK COVERED BY CONTRACT PRICE

(These paragraphs are to U. S. Engineer Office standard paragraphs for such items)

1-13. INSPECTION AND TESTS.

The work, except Model Tests, will be conducted under the general direction of the contracting officer and will be inspected by inspectors appointed by him, who will enforce a strict compliance with the terms of the contract. The inspectors will keep a record of the work done. The presence of the inspector shall not relieve the contractor or his responsible agent of any responsibility for the proper execution of the work.

All materials, supplies and parts and assemblies thereof entering into the work to be done under these specifications shall be tested, unless waived in writing by the contracting officer or his duly authorized representative. If requested in advance of manufacture, the contractor shall furnish the contracting officer with certified copies of tests of materials used in the manufacture of the apparatus. The results of these tests shall be in such form as to provide means of determining compliance with the applicable specifications for the materials used. The cost of making all of the above required tests shall be borne by the contractor.

Unless waived in writing by the contracting officer, all tests and trials shall be made in the presence of a duly authorized representative of the contracting officer. When the presence of the inspector is so waived, sworn statements, in quadruplicate, of the tests made and the results thereof, shall be furnished to the contracting officer by the contractor.

The contractor shall grant the duly accredited representatives of the contracting officer free access to his shops at all times for inspection of manufacture and of materials used. All parts of this equipment will be subject to inspection during any stage of manufacture or erection and any part or parts found unsatisfactory as to design, workmanship, or material will be rejected. Articles, materials, or supplies on rejection by an inspector shall be kept out of or removed from the finished work by the contractor.

The contractor will be required to furnish, upon the request of the inspectors, the use of such laborers and materials forming the ordinary and usual equipment and crews of such plants as may be reasonably necessary for inspecting and supervising the work. The contractor shall furnish all gages and other measuring equipment and instruments necessary for the proper and expeditious inspection of the work.

The contractor shall furnish ample office space at the plant or plants conveniently located to the work for the exclusive use of the Government inspectors. This office space shall be fitted with desks, chairs, tables, lights, heat, file cases, typewriter and electric fans, and janitor service shall be maintained. It shall be convenient to lavatory facilities.

The cost of meeting all the foregoing requirements must be included in the contract prices.

It is understood that any instructions, or decisions given by a superior officer through the contracting officer, are to be considered instructions or decisions of the contracting officer, in all cases where under the terms of this contract decision rests with the contracting officer.

1-14. BASIS FOR EQUITABLE ADJUSTMENTS FOR ADDITIONAL WORK REQUIRED BY CHANGES IN DRAWINGS AND SPECIFICATIONS.

(To be U. S. Engineer Office standard paragraph for this item)

1-15. PHOTOGRAPHS.

The contractor shall furnish the contracting officer with four prints each of progress photographs of the work done in his shop. Photographs shall be taken when and where indicated by the contracting officer or his representative. Photographs shall be 8" by 10" in size, including a one-inch margin on the left 10" side, and shall be mounted on linen. Views taken with the 8" side vertical shall have the title at the bottom 10" side and binding tab at the top; views taken with the 10" side vertical shall have the title at the bottom 8" side and binding tab at the 10" side at the left. It is estimated that approximately 25 photographic negatives of the 67,100 hp turbine and 10 such negatives of the 9,000 hp turbine will be required. Each photograph shall contain upon its face the date, name of contractor, and title of view taken.

1-16. ADJUSTMENT OF PRICES FOR LABOR AND MATERIAL.

1-17. PURCHASE ORDERS.

1-18. FINAL EXAMINATION.

1-19. PROTESTS AND APPEALS.

1-20. PATENTS.

1-21. PREFERENCE FOR DOMESTIC ARTICLES.

1-22. TAXES

1-23. FEDERAL SPECIFICATIONS.

1-24. EXECUTION OF CONTRACT.

(These paragraphs are to be U. S. Engineer Office standard paragraphs for such items.)

SECTION II

DETAIL SPECIFICATIONS

2-01. GENERAL DESCRIPTION.

There will be installed in the Barnhart Island Power house, in each of the United States and Canadian plants, 18 main units of 67,100 hp capacity each and a house unit of 9,000 hp capacity, all of the Francis type.

On account of the large number of units and the probable rapid construction program, it is anticipated that the contract for turbines will be divided between several or all competent manufacturers in the respective countries. Although similarity of details of turbines to be installed in both plants is essential and required, these specifications shall, in general, be considered as being applicable only to the turbines to be installed in the United States plant.

To facilitate design and construction of the power house, it is highly desirable that the water passages from intake entrance to draft tube discharge be of uniform design including, insofar as practicable, the hydraulic design of embedded parts such as speed ring, pit liner and draft tube liner. Uniform mechanical design is also important, although not equally essential.

2-02. HEAD AND OPERATING CONDITIONS.

The elevation of the water surface in the Barnhart Island reservoir will be controlled by the Iroquois Point Dam, about 29 miles upstream of the plant, and normally will be elevation 238. It is contemplated that in the future it may be possible to regulate the headwater, either at Iroquois Point Dam or at the power house, at elevation 242 or 243.

For purposes of design and the making of model tests, the contractor shall assume reservoir and power plant operating conditions as follows:

(a) Initial Operation

Normal head	81 ft.
Range of heads	71.3 to 83.8 ft.
Maximum head for runaway speed	90 ft.
Controlled headwater	Elev. 238
Normal corresponding tailwater	Elev. 157
Maximum headwater (no units operating)	Elev. 249
Minimum tailwater	Elev. 154
Maximum tailwater	Elev. 190

(b) Ultimate Operation

Normal head	83.5
Range of heads	71.3 to 87.3 ft.

2-03. COOPERATION WITH OTHER CONTRACTORS.

If the awards for the turbines and governors for each schedule are under separate contracts, the contractors shall exchange between themselves and the generator contractor, after subsequent award of generator

contract, all necessary drawings, dimensions, templates, gages, and other information required to insure the complete and proper design and manufacture of all connecting or related parts of the turbines, governors and generators.

The contractors for turbines under Schedules A to C inclusive shall cooperate with each other to secure, insofar as practicable, like details for the various items of work as elsewhere herein specified. After selection of types and sizes of turbines or approval of model tests, they shall exchange drawings, templates and gages, and any other necessary information to facilitate uniform mechanical design and the same details for work so mutually agreed upon and for such other work so specified herein.

No extra compensation shall be claimed because of any modifications required to accommodate equipment of another contractor, except as is otherwise specifically provided herein. All adjustments shall be made between the respective contractors without involving extra cost to the Government. Two copies of all drawings and all correspondence relating to drawings and specifications interchanged between contractors shall be sent to the contracting officer, and one copy of each shall be sent to_____.

2-04. MODEL TESTS.

Promptly after receipt of "notice to proceed" the contractor (or contractors) shall be proceed with the design of the turbine (or turbines) proposed and with the construction of a test model for each turbine not less than 16 inches in diameter, exactly homologous with the turbines to be furnished.

The model tests for the 67,100 hp turbines shall be made in uniform spiral casing and draft tube settings in accordance with outlines shown on accompanying drawings or of designs previously agreed upon by the turbine contractors and approved by the contracting officer.

The model test for the 9,000 hp turbine shall be made in scroll case and draft tube setting of the contractor's design, subject only to the following power house requirements:

a. Elevation, center-line of the distributor 163
(67,100 hp unit 100
b. Elevation, draft tube floor (9,000 " " 110

(It is essential that the 9,000 hp house unit in the United States plant be a duplicate, insofar as practicable, of the house unit in the Canadian plant, and the contractors for these turbines shall co-operate to accomplish this.)

The turbine contractors shall so arrange that both the model for and the prototype 67,100 hp turbines under the individual contracts shall have identical dimensions, and same details if practicable, for the following items in addition to the hereinbefore mentioned common water passages:

a. Speed ring, - outside diameter and height of speed ring, and gate circle diameter.

b. Draft tube liner, - except the top section of steel plate liner.

When each contractor is satisfied as to the results of the tests for the first model for the turbine, he shall notify the contracting officer that the performance tests are ready to be run. The contracting officer or his representative will promptly visit the laboratory and witness such tests.

The contractor shall make as many complete turbine models and model tests as required by the contracting officer. After each test the contracting officer will indicate the changes in characteristics which are desirable to be obtained in the next test and the contractor shall so alter or redesign the runner model as to endeavor to secure such changes in characteristics, if practicable.

The contractor and the contracting officer shall jointly select the design that has the proper characteristics to meet the operating conditions and to best satisfy the requirements of these specifications.

In case of disagreement, the final selection of the design from models tested shall be made by the contracting officer, but if any change proposed in the shape of the parts as selected shall appear objectionable or undesirable to the contractor, he shall file with the contracting officer a statement of such objections and reasons therefor, and shall thereafter be relieved of responsibility for any of the effects which can be proved to be the result of such changes, if made.

For the purpose of canvassing bids it will be assumed that three complete model tests will be made by the contractor under each Schedule for the 67,100 hp turbine (the original and two additional model tests,) and the same number of tests for the 9,000 hp turbine. The cost of the original tests (one for each size turbine) shall be included in the contract prices for the turbines. The cost of each additional model test shall be included in the unit contract prices for model tests.

Nothing hereinbefore stated shall be construedas limiting the number of tests which the contractor may wish to make on his own initiative and at his own expense to insure meeting his guaranteed capacities, nor shall any requests of the contracting officer for additional model tests or special characteristics in said models serve to relieve the contractor of his responsibility for guaranteed capacities specified herein.

The contractor shall retain all templates for the accepted turbine model and for the prototype, except that each contractor under Schedules A to D inclusive shall exchange such templates with the other contractors, as may be necessary to assure identical dimensions and details for the agreed-upon common items of work, where so specified or directed. The contractor shall therafter furnish such templates for model and prototype to the Government upon request by the contracting officer, to permit the contracting officer or his representative to assure himself that the prototype turbine is homologous with the model.

2-05. EFFICIENCY AND OUTPUT.

The turbines shall be designed to afford the best efficiency over a wide range of gate openings for the indicated operating heads, and shall develop the specified outputs at 81 foot head, both as follows:

	(a) 67,100 hp Turbine	(b) 9,000 hp Turbine
Rated head, in feet	81	81

Output at best efficiency	61,100 hp	
output, full gate		9,000 hp
Range of best efficiency, net head in feet	73 to 85	73 to 85
(For generator rating - and not for guarantee)		
Output, full gate at 81 ft. head	67,100 hp	
Output, full gate at 85 ft. head	72,200 hp	(Restricted to 9,000 hp)

Whether the specified capacities are met shall be determined by "stepping up" from the model tests, subject only to check by field test, which may or may not be made during the period that the contract is in force.

The capacities of the prototype runners shall be computed from the model tests by ratios of the 3/2 powers of the heads and the squares of the diameters. The Moody formula shall be used to similarly determine the efficiencies of the full size units from the model tests.

No model will be approved unless the peak efficiencies of the prototype runner at heads of 73 to 85 feet inclusive shall be 90% or higher.

2-06. RUNAWAY TESTS.

Within two years after the turbines have been installed and placed in satisfactory operation, or not to exceed three years after completion and offer of shipment, one 67,100 hp turbine under each schedule and the 9,000 hp turbine will be given an overspeed test at the runaway speed at the maximum head as specified by the contractor in the applicable data sheet, accompanying these specifications, or at the equivalent runaway speed at the highest head available at time of test. Each test shall be for not less than 5 minutes after the full speed has been attained with no load on the generator, to determine whether or not the contractor has met the requirements in paragraph 3-01.

2-07. REPLACING DEFECTIVE PARTS.

If during a period of one year after operation is begun, but not to exceed three years after the completion and offer of shipment any parts of the turbines or accessories are found defective because of design, workmanship or material, the contractor shall furnish f.o.b. Massena, New York, replacement parts of design, workmanship, and material approved by the contracting officer. The pitting of turbines beyond the limits specified in paragraph 3-15 will be considered a defect within the meaning of this paragraph.

Should the runner fail to meet this guarantee, the contractor shall furnish a new runner for replacement, f.o.b. Massena, New York, or at the option of the contracting officer, he shall repair the runner by cutting down in the areas showing cavitation to a depth of at least 1/4 inch and building up by welding with stainless steel and grinding smooth to required contour in such manner as to correct and make it equal of a new runner.

2-08. MATERIALS.

All materials used in the construction of the apparatus shall be selected as the best available for the purpose for which used, considering strength, ductility, durability, and best engineering practice. Liberal factors of safety shall be used throughout the design and especially in the design of all parts subject to alternating stresses or shock.

The maximum primary unit stresses for materials used for the head cover, speed ring, runner and other parts subject to hydrostatic pressure or alternating stress, for both the 67,000 hp and 9,000 hp turbines and the scroll case for the 9,000 hp turbines shall not exceed the values in the following table, at the maximum loads occasioned by the most severe operating conditions:

	Maximum unit stress in pounds per square inch	
	Stress in tension	Stress in compression
Cast iron	2,000	8,000
Cast steel	10,000	10,000
Alloy cast steel	17 per cent of the ultimate strength or 27 per cent of the yield point	17 per cent of the ultimate strength or 27 per cent of the yield point
Plate steel for scroll case and other principal parts	12,000	12,000

Alloy cast steel shall have an elongation of not less than 22 per cent and a reduction of area of not less than 30 per cent.

For other materials used in the construction of the apparatus the maximum primary unit stress due to maximum head, and the most severe normal operating conditions shall not exceed one-third of the yield point nor one-fifth of the ultimate strength of the material.

At the breaking point of the yielding links or shearing pins, a unit stress not to exceed two-thirds (2/3) the elastic limit will be allowed in the wicket gates, wicket-gate stems and wicket-gate stem levers.

Unless otherwise specified herein, all materials used in the construction of the apparatus shall conform to latest Federal Specifications where applicable, and where inapplicable, to the latest specifications of the American Society for Testing Materials or of the Society of Automotive Engineers.

If the contractor desires for any reason to deviate from the above standards or to use materials not covered herein, or by Federal Specifications, or specifications of the American Society for Testing Materials, or of the Society of Automotive Engineers, he shall submit a statement of the exact nature of the deviation and shall submit for approval of the contracting officer complete specifications of the materials which he proposes to use.

If requested in advance of manufacture the contractor shall furnish the contracting officer with certified copies of tests of any or all materials used in the manufacture of the equipment. The results of these tests shall be in such form as to provide means of determining compliance with the applicable specifications for the materials tested. The cost of making all of the above required tests shall be borne by the contractor. The contracting officer shall have the right to select additional test specimens of any materials to be used and to make test of the same at the expense of the Government.

The contractor shall, upon request of the contracting officer, furnish complete information as to the maximum unit stresses used in the design or else all information necessary to check the design.

2-09. BRONZE CASTINGS.

Bronze castings shall be of a quality at least equal to that required by Federal Specification QQ-B-691a for "Bronze; Castings", Composition #5.

Bronze bearing bushings, thrust discs, gate ring wearing plates and packing box wearing rings shall conform to Society of Automotive Engineers Specification No. 64 for Phosphor Bronze Castings.

2-10. CAST IRON.

Cast iron shall conform to Federal Specification QQ-I-656 for "Iron, Gray, High-Test (Semi-Steel); Castings."

2-11. STEEL CASTINGS.

Except as otherwise herein required, all steel castings shall conform to Grade 2, Medium, as specified in Federal Specification QQ-S-681a for "Steel; Castings." X-Ray, Gamma ray or Magnaflux examinations will not be required at the expense of the contractor; however, the Government reserves the right to make such examinations at Government expense. The contractor shall submit to the contracting officer before proceeding with foundry work, drawings of all steel castings subject to hydraulic pressure, all turbine gate castings, runner castings and other important castings, showing thereon the locations of tension and bend test specimens. The contractor shall notify the contracting officer, or his authorized representative, in time to have an inspector present at the foundry:

a. When castings are taken out of the sand.
b. When castings are cleaned ready for surface inspection and before any repairs are made.
c. After repairs are completed and before annealing.
d. After annealing and before shipment to the machine shop.

No repairs shall be made to castings without the knowledge and approval of the contracting officer. Welding shall be done only by properly qualified welders and in accordance with the best welding practice. Cracks or other defects disclosed when the castings are cleaned or during machining operations shall be chipped off down to sound, clean metal before any repairs are made. If the removal of metal to uncover the crack or defect reduces the stress-resisting cross section of the casting more than thirty per cent (30%), the casting may, at the option of the contracting officer or his authorized representative, be rejected or repaired. Castings requiring welding repairs at any stage of manufacture after the first annealing shall be re-annealed unless otherwise permitted by the

contracting officer.

Neither the wall thickness nor other dimensions of the castings shall be less than called for on the drawings by an amount sufficient to impair by more than ten per cent (10%) the strength of the castings of the dimensions shown on drawings or to exceed by any amount the stresses allowed under these specifications. Castings shall not be warped or otherwise distorted, nor shall their dimensions be oversize to such an extent as to interfere with proper fit with other parts of the equipment. The structure of the castings shall be homogeneous and free from excessive non-metallic inclusions. An excessive segregation of impurities or alloys at critical points in the castings shall be sufficient cause for its rejection.

2-12. STEEL FORGINGS.

Steel forgings shall be of a quality at least equal to that required by the specifications of the American Society for Testing Materials for Carbon Steel Forgings, Serial Designation A-18-39, Class E.

2-13. STEEL PLATES.

Steel plates for the scroll case and penstock section for the 9,000 hp turbine, for half-sections of pit liners containing the servo-motors, and for speed rings, top and bottom cover plates, and pressure tanks shall conform to the specifications of the American Society for Testing Materials for Low Tensile Strength Carbon-Steel Plates of Flange and Firebox Qualities, Serial Designation A-89-39, firebox quality, Grade B.

Steel plates for the balance of the pit liners, and for draft tubes, sump tanks and other unimportant stress-carrying parts shall conform to the specifications of the American Society for Testing Materials for Steel Plates of Structural Quality for Forge Welding, Serial Designation A-78-39, Grade B.

Rivets shall conform to the specifications of the American Society for Testing Materials for Boiler Rivet Steel and Rivets, Serial Designation A-31-39.

2-14. CORROSION RESISTING STEEL.

a. Corrosion resisting steel (sheet, strip and plate,) except as otherwise herein specified, shall meet the requirements of Navy Department Specification 47S-20a, Corrosion Resisting Steel for Plates, Sheet, Etc., of the following grades:

1. Where specified herein as "18% chromium and 18% nickel", it shall refer to Class 1.

2. Where specified herein as "13% chrome," it shall refer to Class 3.

3. Where specified herein as "17% chrome," it shall refer to Class 4.

b. Corrosion resisting steel for bars and rods shall conform to Navy Department Specification 46 S-18b, Steel, Corrosion-Resisting: Bars, Rods and Forgings, Grade 1A. Where used as sealing strips on wicket gates and like work where stresses will not be transmitted through the corrosion resisting steel bars or rods, the tests described in the aforementioned

specification will not be required and the contractor shall furnish only the chemical test reports for the products to be used.

c. Corrosion resisting steel for castings shall conform to the specifications of the American Society for Testing Materials for Chromium Alloy-Steel castings, Serial Designation A-221-39, Grade A.

2-15. ELECTRIC WELDING - FUSION TYPE.

a. Preparation for welding. Members to be joined by welding shall be accurately cut to size, and where required, shall be rolled or pressed to the proper curvature in accordance with dimensions shown on the drawings. The dimensions and shape of the edges to be joined shall be such as to allow thorough fusing and complete penstration and edges shall be planed if necessary to accomplish this result. The members which are to be welded together shall be in sufficiently intimate contact at the time of welding so that the members will not be forced more closely together with the cooling of the weld, thus setting up additional strains and distortions in the weld and parent metal. The surfaces of the members to be welded shall be free from rust, grease, or scale for a distance one half inch back from the welding edge at the time of welding. Flame cutting may be used in the preparation of the various members providing this operation is performed by a machine supplemented by finishing of edges if necessary in the opinion of the contracting officer. Any contour irregularities at points of critical stresses shall be removed by welding and/or grinding.

b. Welding. The welding of all joints shall be done by a process that will produce complete fusion with the parent metal. All welds shall be free from unsound metal and cracks. Minor imperfections in welds may be chipped out and the defect rewelded subject to the approval of the inspector. The finished depressions and other irregularities and extraneous nodules of weld metal shall be removed by chipping. The size of electrodes, amperage, average depth of individual layers and other details of the welding process used in the manufacture of the parts shall meet with the approval of the contracting officer. Welding procedure, as to direction, length, number and sequence of beads, shall be carefully planned so as to minimize locked up stresses. Distortions due to welding or stress relieving shall not be corrected by blows. All finished welds shall be shot-blasted to remove scale and facilitate inspection. All welds which are subjected to tension or bending shall be done by the shielded arc method, using coated welding rods or a suitable flux, or gaseous envelope to shield the arc and molten metal. All scale or flux shall be removed after each pass. All shop welded parts which will be subject to alternate stresses or shocks shall be stress-relieved in accordance with Navy Department's "Specifications for Welding and Reference Data for Use Therewith." (General Specifications - Appendix 5.)

c. Electrodes. The electrodes used throughout the work shall be suitable for use with the parent metal at each weld. Electrodes shall be received on the job in unbroken packages bearing the manufacturer's label or be otherwise marked. Certified statements shall accompany each shipment of electrodes to the effect that sample pieces, representative of each kind and size in each shipment, have satisfactorily passed the tests required by Navy Specifications 22 W -7C, or the American Bureau of Shipping.

d. Qualifications of Welders. All welding under this contract shall be done only by welders who have successfully passed the qualification tests of the American Bureau of Shipping or of the U. S. Navy Department or under the A.S.M.E. Boiler Construction Code. The contractor shall bear the

expense of conducting these tests, and shall certify by name, to the contracting officer, welders who have successfully passed the prescribed tests. The contractor shall require any welder to repeat these tests when, in the opinion of the contracting officer or his representative, the work of the welder indicates a reasonable doubt of his efficiency. In such cases the welder shall be recertified as above if he successfully passes the retest; otherwise, he shall be disqualified until he has successfully passed a retest.

e. Test Specimens. The contractor shall provide without charge to the Government, all necessary test specimens properly machined for testing and all samples or drillings for analysis, and shall notify the contracting officer or his representative when the test specimens or samples are ready for testing. All test specimens and samples shall be plainly marked to indicate the materials they represent and shall be properly boxed and prepared for shipment if desired. All tests including materials shall be made at the expense of the contractor. Acceptance of apparatus or the waiving of inspection thereof shall in no way relieve the contractor of the responsibility for furnishing apparatus meeting the requirements of these specifications.

2-16. CORROSION RESISTING BOLTS AND NUTS.

Bolts and nuts shall be made of corrosion resisting steel or bronze when used under either of the following conditions:

a. Bolts projecting from the concrete, with nuts subject to removal.

b. Throughout the work when bolts or nuts or both are subject to frequent adjustment or removal, such as adjusting bolts for gland rings of stuffing box, manhole bolts, bolts on man-doors, removable screens, strainers and adjustable bearings.

Corrosion resisting steel for bolts and nuts shall be of quality at least equal to Navy Department Specification 46-S-18b, Corrosion Resisting Steel for Bars, Rods, and Forgings, Class 6.

Bronze for bolts and nuts shall be of quality at least equal to that required by the American Society for Testing Materials standard specification for Naval Brass Rods for Structural Purposes, Serial Designation B-21-29.

2-17. WORKMANSHIP.

All work shall be done and completed in a thorough, workmanlike manner and shall follow the best modern practice in the manufacture of high-grade machinery notwithstanding any omissions from these specifications or drawings. All work shall be done by mechanics skilled in their various trades. All parts shall be made accurately to standard gage when possible so as to facilitate repair and replacement.

2-18. TEMPLATES, GAGES, PATTERNS, ETC.

The contractor shall provide, and retain in storage for at least 10 years, free of cost to the Government, sufficient templates, gages, patterns and records to allow the contracting officer to have major repair and/or replacement parts made to the best and most economical advantage of the United States. Before destruction of such gages, patterns or records at the end of the specified period, the contractor shall notify the contracting officer of his intent to do so.

All special templates and gages necessary for field erection shall be the property of the Government.

SECTION III

TURBINES

3-01. TYPE OF TURBINES.

The turbines shall be of the vertical shaft Francis type, with the 67,100 hp turbines installed in concrete spiral casings and the 9,000 hp turbine installed in a steel plate scroll case. The turbines shall be so designed and constructed that all removable parts, including runner, shaft, guide bearing, guide bearing support, crown plate, gate operating mechanism and the wicket gates can be removed from above. The turbine contractor shall cooperate with the generator contractor, after subsequent award of generator contract, to the end that the largest turbine part required to be passed through the generator stator may be accommodated by the opening through the generator stator.

(a). Head Variation. The head variations under which the turbines will operate are as given in paragraph 2-02.

(b) Speeds. The normal speeds shall be 69.2 r. p. m. for the 67,100 hp turbines and 150 r. p. m. for the 9,000 hp turbine. Rotation shall be in clockwise direction, when viewed from the top down.

All parts of each turbine shall be so constructed that they will withstand, without injury, the stresses induced by the runaway speed of the unit when operating at 90 feet head with no load on the generator.

(c) Capacity - 67,100 hp units. Each main turbine shall have a capacity at best gate of not less than 61,100 hp at an effective head of 81 feet, and a capacity of 67,100 hp, plus or minus 5% at that effective head. At heads higher than 85 feet, the turbine gate openings will be limited so that the maximum output will not exceed 72,200 hp.

9,000 hp unit. The house turbine shall have a capacity at full gate of not less than 9,000 hp at 81 feet effective head. At heads higher than 81 feet, the turbine gate openings will be limited so that the maximum output will not exceed this rated capacity.

(d) Operation. The turbines shall operate at any gate and under any head from 71.3 feet to 87.3 feet, within the limitation set forth under "Cavitation," in paragraph 3-15 without causing objectionable surges in power output, detrimental vibrations or objectionable noises, other than those due to the resonance of the substructure. How ever, the turbine contractor will not be held responsible for any surges, vibrations or noises emanating from any source other than the design, construction and erection of the parts manufactured by him.

The Government will limit the output with such degree of assurance as available protective devices will permit, by load limit stop on the governor and adjustable mechanical stop on the piston stroke of the gate servo-motor and any other approved means. However, the turbines shall be so designed and constructed that a temporary overload, not to exceed 15%, will cause no damage. In making provision for such an overload, the unit stresses may be increased above those hereinbefore specified, but shall not exceed one-half the elastic limit of the metal.

(e) Elevations. The centerline of the distributor or speed ring for both sizes of turbines has been established at elevation 163. For the 67,100 hp turbines, the low point of the floor of the draft tube immediately downstream of the centerline of the turbine has been established at elevation 100, and for the 9,000 hp turbine the floor of the draft tube has been established at elevation 110.

3-02. RUNNER.

The runner for each size turbine shall be made of cast steel and so constructed as to be readily removable from the shaft. For the 67,100 hp turbines, each runner shall be made in one piece, or in the minimum number of pieces permitted by manufacture and shipping features, arranged for assembly by the contractor at the site and fastening together rigidly and securely by means of shrink rings.

The runner for the 9,000 hp turbine shall be made in one piece.

The runner shall be designed to support its own weight and the weight of the turbine shaft, when the latter is disconnected from the generator shaft and the runner is resting on a ledge or shoulder in the lower section of the speed ring.

The runner shall be provided with renewable seal or wearing rings properly seated in the hub and bands. The upper and lower seal clearances of the runner shall be such that the runner can be lifted not less than 5/8 inches on the 67,100 hp turbines and 3/8" on the 9,000 hp turbine, in order to repair the generator thrust bearing.

All surfaces exposed to the flow of water shall be finished smooth by grinding or other means so that they will be true to designed shapes and free from hollows, depressions, cracks or projections which might cause cavitation or pitting.

A cone attached to the hub shall be provided to guide the water as it leaves the runner. The runner shall have vent holes through the hub to relieve pressure under the head cover.

The entire runner for the 9,000 hp turbine shall be statically balanced before leaving the shop. The runner for each 67,100 hp turbine shall be similarly balanced in the shop if built in one piece, and if assembled at the site, it shall be statically balanced by the contractor after assembly and any necessary machining, etc., have been completed.

3-03. SHAFT.

The shaft shall be forged open-hearth carbon or alloy steel, properly heat treated and of ample size to operate without objectionable vibration or distortion at any speed up to full runaway speed. It shall have a forged flanged half coupling on the upper end for connecting to the half coupling on the lower end of the main generator shaft and a similar half coupling on the lower end for bolting the shaft to the runner by means of heavy steel bolts. The generator contractor for each unit will furnish the template for his half of the coupling to the turbine contractor.

The turbine shaft shall be accurately machined all over and polished where it passes through the guide bearing. The shaft for each 67,100 hp turbine shall have a hole at least 6 inches in diameter bored axially throughout its entire length and the shaft for the 9,000 hp turbine shall have a similar hole at least 4" in diameter. The machining of the bore shall be sufficiently smooth to permit visual inspection of the metal in the interior of the shaft.

The generator shaft for each unit, complete with thrust block and thrust collar, will be shipped to the turbine contractor who shall furnish the coupling bolts and nuts and ream the holes in the generator and turbine coupling flanges and fit the coupling bolts. The turbine contractor shall check shaft sections individually, and then assemble the generator shaft and the section of turbine shaft on trunnions or vertically for alignment check of the entire shaft. Tolerances for the shafts, bearing surfaces and coupling flanges shall be as follows:

Individual Turbine and Generator Shafts.

All cylindrical portions of shafts shall show not more than .0015 inch on the indicator, or .00075 inch from straight. Faces of coupling flanges and thrust bearing faces shall show a maximum of .00075 inch on the indicator.

The male projection of the turbine shaft shall show a maximum runout of not more than .001 inch. The surface of the shaft at the turbine main bearing shall show not more than .001 inch on the indicator.

Combined Turbine and Generator Shafts.

All cylindrical portions of the shaft including guide bearing surfaces shall show not more than .003 inch on the indicator, or .0015 inch from straight. Thrust bearing faces shall show a maximum of .0015 inch on the indicator.

Alignment shall be withessed and approved in writing by the generator contractor, the turbine contractor and the contracting officer.

Any corrections to the generator and turbine shaft shall be made immediately, the turbine and generator contractors cooperating to effect this so as to minimize any delays and adhere to the shipping schedules. The turbine contractor shall receive and load the generator shaft, for shipment to the power house of the Government, at his expense. Shipment will be made on Government bills of lading at Government expense.

A male and female type of coupling shall be furnished, the tongue of the male half to be on the turbine shaft and to be approximately 3/8 inch high. The turbine and generator contractors shall cooperate to provide a sliding fit between the two halves of the coupling.

All coupling bolts shall be a close machine fit and of dimensions consistent with the remainder of the design. Taper bolts shall not be used. The coupling bolts shall be provided with suitable locking devices to prevent the nuts from turning loose.

The coupling flanges and bolts shall be designed for lifting the runner and shaft with four coupling bolts.

The contractor shall provide a bolt press or jack if needed for inserting and removing the coupling bolts. This bolt press or jack shall become and remain the property of the Government.

The turbine shaft shall have a removable and renewable sleeve of corrosion-resisting steel (18% chromium and 8% nickel composition or equal) where it pass es through the stuffing box and shall be enlarged and polished where it passes through the guide bearing in the turbine head cover. For the 9,000 hp turbine the shaft shall also be enlarged and polished where it passes through the intermediate support bearing.

A steel or aluminum deflecting skirt shall be provided below the bearing oil reservoir to prevent inter-mixture of water with bearing oil as a result of a stream of water shooting upward through a possible break in the stuffing box packing.

Just above the main bearing housing a circumferential line shall be scribed on the shaft, and an adjustable pointer shall be mounted on the bearing housing opposite this line to indicate if any lowering of the shaft occurs, and to permit re-alignment after thrust bearing dismantling. The shaft shall be gound and polished at convenient location below the coupling and

above the main bearing to faciliate checking alignment.

The shaft for each 67,100 hp turbine shall have a height of 21 feet above the center line of the distributor, or to elevation 184; the shaft for the 9,000 unit, including the intermediate section, shall have a height of 32 feet above the distributor center line, or to elevation 195. (For purposes of designing the shafts for stability and strength, the center line of the generator guide bearing for each 67,100 hp unit shall be considered as being at elevation 197 and for the 9,000 hp unit at elevation 204. The intermediate support bearing for the latter unit shall be located with its center line at elevation 185.)

3-04. GUIDE BEARINGS.

The main turbine guide bearing shall be of approved height, of babbitt-lined, oil lubricated type, or approved equal, located above the runner and shall consist of a bearing support and a removable bearing shell. The bearing shall be located as close as possible to the runner, consistent with convenient access to the main packing gland. It shall be so arranged as to permit at least 5/8 inch vertical movement of the runner and shaft for adjusting and dismantling the generator thrust bearing, for each 67,100 hp unit; and a vertical movement of 3/8 inch for the 9,000 hp unit. The guide bearing support or housing shall be of steel castings of heavy construction, supported on the head cover and designed to hold the bearing shell rigidly. The bearing housing and bearing shell shall be split vertically into two sections to faciliate dismantling.

An intermediate guide bearing shall be provided for the 9,000 hp turbine, with its supporting frame or spider rigidly carried or supported at the outer diameter by the pit liner. The bearing shell shall in all its details be similar to the bearing shell of the main guide bearing of the turbine.

The bearing shell shall be lined with babbitt similar and at least equal to Selby Diesel Engine babbitt or Tuftex No. 20 alloy, accurately bored, and suitably grooved for oil circulation. The final fitting and scraping of the bearing will be done in the field, to insure proper fit on the shaft. Suitable lifting eyes and backing out studs shall be provided to facilitate removing and installing the bearing shell segments and the bearing in a minimum amount of time.

Lubrication of the turbine guide bearing (or bearings) shall be effected by oil circulated through the bearing (or bearings). The circulation shall be from an oil reservoir in the bottom of each bearing to the oil pumps, and thence through the bearing, and after passing through the bearing the oil shall be returned to the oil reservoir. A standard oil level gage glass shall be provided in the oil reservoir, giving clear vision of the oil to the bottom of the reservoir, to indicate the amount of water in the reservoir. The gage shall be provided with drain cock to remove the water. If cooling is necessary, the oil shall be circulated through suitable cooling coils immersed in circulating cold water. Cooling coils shall not be placed in the guide bearing housing. The lubricating oil system for each turbine shall have sufficient capacity to supply the required amount of oil to the turbind guide bearing (or bearings), and the oil reservoir shall have sufficient capacity to hold all the oil in the entire bearing system.

Two independent, motor-driven positive displacement, rotary type, oil pumps shall be provided for circulating the lubricating oil. The pumps shall be mounted in a recess or alcove provided in the turbine pit liner above elevation _____. One of the oil pumps shall be driven by a 60-cycle, 3 phase, 230 volt, alternating current motor, and the other pump shall be driven by a 125 volt, direct-current motor; power for the latter

will be supplied from the station storage battery. The pump motors shall have enclosed conduit boxes and shall be reasonably protected against moisture. Capacity, speed and torque of the motors shall be designed for full voltage starting and shall conform to A.I.E.E. Standards.

Normally the oil shall be circulated by the alternating current motor pumping unit, but the direct current motor shall be arranged to start automatically and supply oil to the bearing (or bearings,) upon failure of the alternating current supply. An alarm shall be provided to operate upon the failure of the alternating current pumping unit.

A flow indicator shall be provided on the discharge of the oil circulating system for each bearing, with connection to operate an alarm and indicating light on the switchboard.

The contractor shall provide manually operated control switches and overload protection for each pump motor, to be mounted on the auxiliary panel specified in paragraph 3-17.

The contractor shall furnish the complete lubricating system for the turbine guide bearing (or bearings), including the oil reservoir, cooling chamber, if any, sight flow gages, oil level indicators, all piping between the turbine bearing, pumping units and oil reservoir, all necessary temperature relays, indicators and detectors as specified in paragraph 3-17, and relays for remote annunciator indication at the switchboard or at the actuator, and other accessories for the automatic operation of the oil circulating system. All oil piping shall be brass, with brass valves and fittings.

All external wiring beyond the limits of the turbine pit for the motors, alarms, and shutdown features will be supplied by the Government.

The main guide bearing shall be so designed and located with reference to the main stuffing box beneath it as to permit ready access to the latter for maintenance without removing the guide bearing.

Each bearing shall have removable top cover plates to prevent dirt or foreign matter working its way into the bearing.

Under any condition of normal operation, from no load to full load, no water shall enter the lubricating oil system, and there shall be no appreciable loss of oil by leakage past the lower oil shedder or by overflow from any part of the oil system. An initial supply of lubricating oil shall be supplied by the contractor.

Stuffing Box. The shaft stuffing box shall be provided with a lantern ring, designed to be easily removable, securely held to prevent rotation with the shaft, and provided with connections for water lubrication. Approved packing rings shall be provided above and below the lantern ring. The stuffing box gland shall be removable, of aluminum alloy, split vertically and provided with corrosion resisting bolts. The lantern ring may be omitted on a showing of better or equally good substitute design.

A suitable water line of copper tubing shall be provided by the contractor to the stuffing box for its lubrication, one branch of this line to go through the wall of the stuffing box to the lantern ring and the second branch to carry water for circulation around the top of the stuffing box. The Government will bring in clear water supply to one point in the turbine pit and the contractor shall provide all other piping, fittings, valves, etc. required in the turbine pit, carrying piping under turbine deck, concealed as far as practicable.

Nothing in these specifications shall be construed to prevent the contractor from furnishing an approved synthetic rubber, non-adjustable, spring-retained packing.

3-05. SPEED RING.

The speed ring shall be designed to withstand all stresses to which it may be subjected during installation, operation and dismantling, including those caused by the weight of structure and machinery loads from above with the spiral casing or the scroll case empty so that it shall become an integral part of the structure.

The speed ring shall consist of welded plate steel or cast steel in radial secions to permit shipment by rail, properly flanged for securely bolting together in the field. If cast steel vanes are used, they shall be cast integral with upper and lower rings; or if welded steel plate is used, the vanes shall be shop welded to the upper and lower rings. If speed ring is made of welded plate steel, the upper and lower curb rings shall be die formed before welding to vanes.

Provision shall be made in the speed ring for each 67,100 hp turbine to put the vanes in tension, inasmuch as the upward reaction at the speed ring due to water pressure in the spiral casing will exceed the weight of the generator and intervening structure for part of the circumference. The contractor shall provide a sufficient number of large diameter reinforcement bars, upset at one end and threaded and attached to the upper ring of each 67,100 hp turbine, for that portion of the circumference where excess water pressure will exist. The threaded ends shall be inserted through holes in the speed ring rims or flanges and provided with double nuts, except that, at ribs, flanges and wherever through bolts can not be placed, the rods shall be threaded into tapped holes in the speed ring. Each rod shall extend sixty (60) diameters beyond the point of attachment.

The speed ring for the 9,000 hp turbine shall have the top and bottom flanges notched and drilled for riveting to the steel plate scroll case.

Flanges shall be provided on each speed ring for connections to the pit liner, to the head cover and to the discharge ring if one is used, or to the bottom plate. One vane in the speed ring for the 67,100 hp turbine shall be made V-shaped to form the tip of the concrete spiral casing or deflector wall. The baffle vane in the speed ring for the 9,000 hp turbine shall have an adequate connection to the scroll case. Two guide vanes in each speed ring shall be cored for discharge pipes to drain the head cover leakage.

The diameter of each size speed ring shall be sufficient to avoid appreciable overhang of the control gate tips over the curve of the curb ring when the gates are open, and such overhanging portion of control gates as may be found unavoidable shall be streamlined toward the bottom to prevent disturbance in the water.

Speed ring vanes shall be made streamlined and shall be curved in horizontal section to guide the entering water from essentially tangent direction to the proper entrance angle.

Each section of the speed ring shall be provided with eyebolts or lugs for attaching slings for handling. A sufficient number of pads shall be provided for the application of jacks and a corresponding number of suitable jacks shall be provided for leveling the speed ring during erection and supporting it in proper position while the surrounding concrete is being placed. Anchor rods or hold-down bolts shall be provided to restrain any upward movement of the speed ring during concreting operations and to subsequently tie it to the concrete supporting ring.

Large holes shall be provided in the speed ring to facilitate pouring of concrete underneath same and 1-1/2 inch tapped holes midway between for final pressure grouting of speed ring foundations. Cover-plates shall

be provided for welding the larger holes shut, and suitable plugs shall be provided for the grout holes.

3-06. SCROLL CASES AND PENSTOCK.

(a) 67,100 hp Turbines -- Scroll Cases. The scroll case (or spiral casing) shall be of the type and outline as shown on accompanying drawings, of elliptical section with axes of about 4 to 3 ratio, formed in the power house substructure. The contraction in the upper portions shall be rapid, and the velocity of the water shall be continually increased up to approximately 13.3 feet per second at the longitudinal centerline or beginning of the true scroll case section.

(b) 9,000 hp Turbine -- Scroll Case. The scroll case shall be of the full spiral type, of plate steel and designed for 100 feet hydrostatic head. All longitudinal joints shall be riveted and caulked. Shop circumferential joints may be welded or riveted. Field circumferential joints shall be riveted. Rivet holes shall be sub-punched and reamed to size in shop assembly. Where the spiral casing attaches to the speed ring, provisions shall be made for caulking the joint in the field in an approved manner.

The scroll case shall be completely shop assembled and attached to the speed ring to assure correct fit. The pieces shall be riveted in a large sections as can be shipped and shall be matchmarked to facilitate assembly in the field.

A sufficient number of erection and fitting-up bolts shall be provided for complete assembly in the field, and all necessary field rivets plus ten per cent (10%) extra of each size required shall be furnished.

A suitable number of supporting brackets and lugs with hold-down turn-buckles shall be provided for supporting and holding the scroll case in position while concrete is being placed.

The contractor shall provide a manhole 24 inches by 36 inches in size with hinged cover, flush with the inside, for access to the scroll case. It shall be furnished complete with gasket, bronze hinge pins and nuts and corrosion-resisting bolts and backing-out screws, and with pet cock and gage.

A saddle flange complete with gasket and bolts shall by provided on the bottom of the scroll case inlet for the connection of a 12-inch drain valve.

The contractor shall tap the s croll case and insert stainless steel piezometer type taps for four connections for turbine flow meters, Winter-Kennedy or equal, and four connections for net head piezometers. The details of the design and location of the piezometer taps will be furnished by the contracting officer. The piezometer piping will be furnished by the Government.

(c) 9,000 hp Turbine -- Penstock. The contractor shall provide the penstock section that is to be attached to the upstream end of the steel scroll casing, the penstock to be 10' -6" diameter and 18 feet long, and designed for 100 feet hydrostatic head. It shall be made of the same steel plate and similarly to the steel scroll case, and shall be fabricated in the shop in as large sections as can be shipped. The pieces shall be matchmarked to facilitate assembly in the field, and shall be shipped nested.

Angle stiffener rings shall be provided at the upstream end and intermediate points, to stiffen the penstock, during erection and while placing concrete, and to provide water cut-offs.

3-07. HEAD COVER AND CROWN PLATE.

(a) 67,100 HP Turbines. The head cover shall be of cast steel or

welded steel and properly sectionalized for shipment and handling, and shall be made in two units. It shall have a circumferential joint inside of the gate circle of such diameter that the central portion of the head cover, guide bearing, runner and turbine shaft can be completely removed or installed without disturbing the control gate bearings and packing glands. Sutiable lifting devices shall be provided at four points of attachment on the head cover for lifting this complete assembly with the crane.

The annular rings of the head cover shall have heavy flanges properly designed so as to prevent undue deflection, and shall be bolted in position by means of ample number of corrosion resisting bolts. The inner cover plate shall be machined as required for receiving the main shaft bearing and stuffing box. A seal or wearing ring shall be provided to mate with that on top of the runner. The outer cover plate shall be machined for proper mounting and shall have noncorrosive bushing and adjustable bronze packing glands for the gate stems.

Removable wearing plates of "13% chrome" corrosion-risisting steel shall be provided in the outer cover plate above the wicket gates, the exposed surface to form an annular ring located to match the points of contact between the gates when in their closed position. The wearing plates shall be attached with corrosion resisting screws.

The underside of the head cover shall be designed to minimize friction and eddy losses between the cover and the runner and the space between shall be adequately drained to relieve water pressure and to minimize hydraulic thrust and leakage.

An automatic valve to be operated by the gate movement shall be provided by the admission of air to the space below the runner. The valve shall act as a check valve, or be provided with a separate check valve, to prevent the outflow of air or water and shall be adjustable for different gate positions. The contractor shall furnish all piping in the turbine pip up to the pit liner, suitably flanged at its terminii at the liner. The piping will be continued from that point by the Government.

Eyebolts shall be furnished by the top of each head cover section for use in crane lifting. A walkway of removable sections of grating shall be provided over the head cover.

(b) 9,000 HP Turbine. The head cover shall be of cast steel or welded steel and properly sectionalized, if necessary, for shipment and handling. It shall not be made in two units, with a circumferential joint inside of the gate circle, - but in all other respects shall be in accordance with applicable details hereinbefore specified in sub-paragraph 3-07(a)

(c) Field Machining of Seal Rings. For the 67,100 hp turbines, the contractor shall not machine the seats for the stationary wearing rings on the outer head cover places and on the bottom plates (specified below) to the final diameters, but shall leave sufficient stock so that the seats may be ground or machined in the field to final diameters and thereby insure that they will be true circles concentric with the vertical centerlines of the units. The contractor shall provide suitable motor-driven boring apparatus, complete with tools, for machining the stationary wearing ring seats after the speed rings have been completely assembled and embedded in the concrete foundations and the turbine outer head cover and bottom plates and the main bearing housings erected and aligned.

Alternate. The contractor shall state, in the space provided therefor in the schedule, the reduction that will be made in the bid price if the aforementioned boring apparatus and tools, are not required to be furnished.

3-08. BOTTOM PLATE. The bottom plate shall be of cast steel and shall be sectionalized as necessary to facilitate shipment and handling, except that the bottom plate for the 9,000 hp turbine shall preferably be in one piece. The bottom plate shall be designed to be bolted to and to be removable from the speed ring and the discharge ring. The contact surfaces between the bottom plate and the speed ring and the discharge ring, shall be machined. A seal or wearing ring shall be provided to mate with the ring on the lower band of the turbine.

The bottom plate shall be machine finished where needed and drilled and bronze bushed as required to receive the lower ends of the gate stems. The bushings shall be lubricated by grease forced through the hollow gate stems. Removable "13% chrome" corrosion-resisting steel wearing plates, attached with corrosion resisting screws shall be provided to form an annular ring located to match the points of contact between the gates when in their closed position.

3-09. TURBINE DISCHARGE RING. The discharge ring shall be of cast steel, suitably sectionalized, if necessary for shipment, designed to be permanently set in the concrete substructure, and heavily ribbed to secure proper anchorage to the concrete. It shall be securely bolted to the speed ring and shall extend to below the bottom of the runner. The upper face of the discharge ring shall form a seat to which the bottom plate shall be securely bolted. The lower end shall be arranged for convenient and accurate attachment to the draft tube liner and shall be provided with a flange to support the turbine runner and shaft when the latter is disconnected from the generator shaft. Suitable pads, jacks and anchor bolts shall be provided to support and level the ring while being attached to draft tube liner and concreted in place. Suitable grout holes shall be tapped in the upper face if necessary and plugs furnished.

The speed ring and discharge ring may be combined in on ring if better suited to the contractor's design.

3-10. GATES AND OPERATING MECHANISM. The turbine wicket gates and gate stems shall be made either of steel castings with each gate and its gate stem cast in one piece, or welded steel secured to forged steel stems. At the top and bottom of each gate and on the closing edges there shall be welded stainless steel, 18-8 or equivalent, to a depth of 3/8 inch. Each gate shall be accurately machined and finished and all gates shall be interchangeable. Each gate stem shall be provided with three bronze-bushed, grease-lubricated guide bearings, one located in the bottom or curb plate and the other two located in the head cover or crown plate, one below and the other above the stuffing box. Each gate stem shall also be provided with thrust bearing of corrosion resisting steel, 13% chrome, against bronze or equivalent. Provision shall be made for adjusting and maintaining the adjustment of the gates in mid-position between the bottom and crown plates. The gate stems shall be drilled and piped for their entire length for grease lubrication of the lower stem bearings in the bottom plate. Approved packing shall be used in the stuffing boxes in the crown plate.

All parts having relative motion in contact shall be properly bushed with broze bushings and gate stems and other mating surfaces in contact with water shall have 13% chrome corrosion resisting steel sleeves. All surfaces shall be provided with convenient and adequate means for forced grease lubrica tion.

The contractor may furnish, as an alternate, approved non-adjustable spring-retained rawhide leather packing.

Operating Mechanism. The gate operating mechanism shall be of ample strength to withstand maximum load that can be imposed on it by the most severe operating conditions. The designs and construction shall be such that lost motion and wear will be reduced to a minimum and means shall be provided for adjusting the position of any individual gate independently of the others, in order that each gate will make close contact with adjacent gates in closed position, and all gates shall have equal, insofar as practicable, simultaneous openings. Ample surplus adjustment shall be available to compensate for future wear and distortion.

A suitable link, shearing pin or other part shall be provided between each gate stem and the gate shifting ring which will be strong enough to withstand the maximum operating forces, but will break or yield and protect the rest of the mechanism from injury in case one or more of the gates become blocked. The yielding link shall be designed to fail with the breaking force in either direction. At the breaking point of the yielding link or shearing pin, the unit stresses may be increased to limitations specified in paragraph 2-08.

Stops shall be provided to limit the angle of movement of the gate stem levers in case of breakage of the above specified protective device, so that interference of the loose gate with operation of the other gates will be prevented. The design of the operating mechanism shall be such that the failure of the yielding link will not interfere with the operation of the other parts.

The entire operating mechanism and connections for controlling the gates shall be readily accessible for inspection, adjustment and repair. The gate shifting ring shall be of cast steel and shall be properly guided by renewable bronze guide strips.

The shifting ring and gate mechanism shall be so located that they do not need to be distrubed to dismantle and replace the main guide bearing shell and accessories.

Provision shall be made by the turbine contractor for the connection of the governor restoring mechanism to the turbine shifting ring.

3-11. GATE OPERATING CYLINDERS (SERVO-MOTORS). Each turbine shall be provided with two oil-pressure operated, double action, hydraulic cylinders having a combined capacity sufficient to supply the maximum force necessary to operate the gates under all conditions of head and load with a minimum oil pressure of 250 pounds per square inch. The maximum operating oil pressure shall be 300 pounds per square inch, and the cylinders shall be tested in the shop at 450 pounds pressure.

With the gate operating cylinders shall be included a suitable mechanical locking device by which the turbine gates may be held securely in the open and closed position against maximum governor oil pressure in the cylinders. The mechanical locking device for holding the gates in the open position shall be so designed that the device can be locked or otherwise rendered inoperative while the turbine is in service. A manually adjustable blocking device shall be provided to limit the gate opening when the head is so high as to develop more than the capacity of the generator. This block shall be readily adjustable for different gate openings to suit different heads.

Suitable automatic means shall be provided to retard the rate of movement of the gates after they have closed beyond speed-no-load position and just before they have completely opened.

The balance of the gates shall be such that at the oil pressure of 250 pounds and with adequate supply of oil to maintain this pressure

throughout the stroke, the servo-motors shall be capable, under the most unfavorable operating head conditions, of moving the turbine gates through and opening or a closing stroke corresponding to the established maximum capacity under any operating head conditions in five (5) seconds. The servo-motors shall be so designed and located that the force for moving the turbine gates is approximately equally divided between the two cylinders and applied in substantially equal magnitude on opposite sides and tangentially to the curve of the gate shifting ring. Oil under pressure, for operating the servo-motors, shall be controlled by the governor actuator.

The servo-motor cylinders shall be made of semi-steel and shall be provided with suitable ports at each end for the admission and discharge of the operating oil. The cylinders shall be accurately bored, provided with flanges for the connecting oil piping, and with stuffing boxes for preventing leakage of oil along the piston rods. The cylinders shall be mounted on machined surfaces on the turbine casing or pit liner. The pistons of the servo-motors shall be of cast steel or cast-iron and shall each be fitted with not less than three cast-iron piston rings suitably shaped to give close contact and uniform pressure on the cylinder walls and prevent leakage of oil pa st the pistons. Suitable drain valves and piping shall be furnished to drain each end of each cylinder. Taps shall be provided on each end of each gate servo-motor for use in inserting pressure indicators and to permit bleeding the pressure in case of shut-down.

The servo-motor cylinders shall be provided with indicators to accurately indicate the gate positions.

3-12. WEARING RINGS. Removable and renewable wearing rings of corrosion-resisting steel and bronze shall be provided where there are close running clearances between the runner and the stationary parts of the turbine. The rotating wearing rings on the runner shall be corrosion-resisting steel containing 11.5 to 13.5% chromium, and at least equal to Type 405, Allegheny 33. The stationary rings shall be bronze, of a quality at least equal to that required by Federal Specification QQ-B-691a, Composition #5, or other suitable approved materials. The wearing rings shall be securely fastened in place by approved means. The radial clearance between the moving and stationary rings shall be as small as possible, consistent with safe operation and with the clearances in the turbine and generator guide bearings. The arrangement of the rings shall permit at least 5/8 inch vertical movement of the 67,100 hp turbine runner and a vertical movement of at least 3/8 inch of the 9,000 hp turbine runner. Provision shall be made to supply water to the spaces between the runner and the stationary rings for cooling and for lubrication when motoring the unit with the gates closed.

3-13. TURBINE PIT LINER. The turbine shall be provided with a heavily ribbed welded-steel plate or cast-iron pit liner to be anchored to the concrete. It shall extend to elevation _____ and shall contain a recess or alcove of suitable size for the lubricating oil pumps. (The recess shall be above elevation _____.) The pit liner shall be made in sections with bolted flanged connections and shall have a flange on the bottom for bolting to flange on the speed ring. Provisions shall be made for accommodating the servo-motors and to withstand their reactions if necessary.

3-14. DRAFT TUBE AND LINER. The concrete portion of the draft tube will be built by and at the expense of the Government.

The contractor shall furnish a plate-steel draft tube liner which shall extend from the bottom of the turbine discharge ring to 15 feet below the bottom of the runner at the centerline of the draft tube. The plate

steel liner shall have welded shop joints and the interior of the lining shall be smooth and shall have no abrupt changes in direction.

Field joints between sections of the steel lining shall be made by riveting with outside butt straps and counter sunk rivets on the inside. The sections shall be made as large as possible to reduce the number of field joints to a minimum. The joint between the steel liner and the turbine discharge ring shall be arranged for convenient and accurate field assembly by method to be agreed upon and approved by the contracting officer.

The draft tube liner shall be of one (1) inch plate for each 67,100 hp turbine and of 1/2 inch plate for the 9,000 hp turbine, heavily reinforced on the outside by means of suitable ribs or structural steel shapes and shall be provided with adequate means for anchorage to the surrounding concrete of the power house substructure.

One rectangular manhole not less than 24 inches wide by 36 inches high, with flush interior surfaces and with hinged and bolted outward swinging cover, securely fastened to the plate steel lining, shall be provided to allow access to the under side of the runner for inspection and repairs. The door shall have bronze hinge pins, bronze-bushed, and bronze bolts, and shall be provided with jack screws for forcing it off its seat. A test cock shall be provided to determine if the water level in the draft tube is below the sill of the door.

Holes for pressure grouting shall be provided in the draft tube liner, such holes to be of proper diameter and spacing for the most efficient job of grouting, and shall include holes for the relief of air pressure. All holes shall be tapped and provided with flush plugs for closing.

3-15. CAVITATION. The contractor shall guarantee the runner against excessive cavitation or pitting for a period of (1) one year from date it is placed in service, or not to exceed three (3) years after completion and offer of shipment. The contractor's guarantee of the runner against cavitation or pitting shall cover only normal turbine operation from one-quarter load up to the cavitation limit, with the limitation that operation at loads less than 50% of the rated capacity shall be for less than _____% of the time.

Excessive cavitation or pitting of the runner shall be defined as the removal of 150 lbs. or more of metal from each 67,100 hp turbine runner and 25 lbs. or more of metal from the 9,000 hp turbine runner. The cavitation or pitting shall be uniformly distributed over the entire surface affected. Erosion or damage caused by suspended matter in the water, or corrosion caused by the chemical composition of the water, are not intended to be covered by the contractor's guarantee.

3-16. DRAINS AND PUMPS. Adequate drain pipe connections and piping shall be provided for removing any leakage that may occur within the turbine pit. Two drainage sumps shall be provided in the bearing support section of the cover plate with discharge through pipes in cored-out vanes in the speed ring. These sumps shall each be provided with suitable intake screens easily accessible for inspection and cleaning. One drain line shall be drained by suction from the draft tube and shall be furnished with a check valve and a gate valve with extended stem above the floor grating. The other line shall be drained by an ejector, complete with solenoid-operated valve, float and float control, on the pressure line. The contractor shall furnish all pipe, fittings, etc., except electric wiring for complete drainage.

3 -17. GAGES, RELAYS AND THERMOMETERS. The contractor shall furnish the following accessories with each turbine:

a. Dial indicator for the shaft alignment, permanently mounted at the top of the bearing.

b. One compound indicating pressure and vacuum gage for the pressure under the head cover.

c. All necessary fittings and pipe for Winter-Kennedy, or equal, indications on each turbine.

d. One standard 10-ohm temperature detector in each segment of the bearing, and one bearing temperature relay in the bearing so located as to indicate the hottest spot and with leads to a terminal board to be located in the turbine pit. The temperature detectors will be connected to temperature indicators to be furnished by the Government. The temerature relays shall be similar and equal to the General Electric Type TB-2 which closes a pair of contacts when the temperature reaches approximately 105° C.

All gages shall be graduated in feet of water. The gage to show vacuum or pressure under the head cover will be mounted in the turbine pit. The gage shall be designed for flush mounting, with flanges, faced to the surface of the pit and furnished with suitable panel. The manometers and registers for turbine flow recording will be installed by the Government in the control or switchboard room.

The contractor shall supply all piping to the gages, of 125-lb. standard iron-pipe size copper tubing, with all necessary 125-lb. standard unions and fittings. Shut-off cocks shall be provided at all gages and also at all points where the piping connects to the main apparatus.

Auxiliary Panel. All switches, relays, motor controls and all other electrical equipment for each unit, not specifically indicated to be mounted elsewhere, shall be mounted on an auxiliary panel to be furnished and wired by the switchboard contractor to be named later. Each contractor shall furnish the specified equipment for his contract, all to match in appearance, as approved by the contracting officer, to provide uniform appearance and operation.

3-18. STAIRWAYS, PLATFORMS AND LADDERS. The contractor shall furnish working, operating, and inspection platforms of approved grating where necessary in the turbine pit. All turbine pit equipment shall be easily removable for dismantling the turbines from above.

3-19. LUBRICATION. A "one shot" centralized lubrication system shall be installed on each turbine, and shall lubricate all of the working parts of the turbine except the main and intermediate shaft guide bearings. This covers lubrication of the gate stem bearings (three per gate stem), gate shifting ring, servo-motor connecting rods at the gate ring connection, and gate links.

The grease shall be distributed by two circular brass pipes, one mounted on the gate shifting ring, the other outside of the gate stem circle. Solid connection shall be used as far as practicable. The grease piping shall be carefully installed in order that there will not be possibility of any leakage or breakage. To this end the piping system shall be tested under

1,000 lbs. per square inch pressure.

The system shall be "Farval" single line type or equal or approved by the contracting officer. The compressor shall have ample capacity for complete greasing three times a day for eight days. Compressor shall be furnished with a pressure gage.

3-20. BOLT GUARDS. The contractor shall provide suitable metal covers or bolt guards to cover the bolt heads and nuts on the turbine and generator halves of the coupling.

3-21. SPARE PARTS. The following spare parts for each turbine shall be furnished by the contractor. All spare parts furnished shall be interchangeable with and of the same materials and workmanship as the corresponding parts of the turbine.

1 - Main turbine guide bearing shell completely lined with anti-friction metal.
1 - Intermediate guide bearing shell, as above, (for 9,000 hp turbine only)
4 - Wicket gates and stems completely machined.
4 - Gate stem levers.
20 - Breaking links for gate-operating mechanism. Gate stem bearing bushings sufficient for three stems.
1 - Complete set of packing and cup leathers for all parts where used.
1 - Complete set of cup leather molds. (if cup leathers are used).
3 - Oil strainer screens.

3-22. WRENCHES, TOOLS, ETC. The contractor for each schedule shall furnish with each size turbine a complete set of case-hardened wrenches and any special tools, lifting slings or other equipment that may be required or convenient for the assembling and dismantling of any part of the turbine, including attaching and removing the runner from the shaft. The bidder shall submit with his proposal a complete description and list of the special tools and equipment which he proposes to furnish. There shall also be included all bolts, studs, pressure grease fittings, lubricating devices, packing, gaskets, and all other appurtenances that may be required to make the turbines complete units ready for operation. The turbine wrenches and special tools shall be mounted on a neat metal board with each item numbered or marked for ready identification.

3-23. SHOP ERECTION AND TESTS. Prior to shipment, the turbine shall be assembled in the shop, to the greatest possible extent, and tested for trueness of gate movement, top and bottom clearances, accuracy of closure contacts with adjacent gates and all other features of mechanical accuracy in runners, shafts and casings. Any imperfections shall be corrected and the turbine parts then match-marked (and dowelled when considered necessary by the contracting officer) to insure correct assembly and alignment in the field.

The steel-plate turbine pit and draft tube liners for all turbines and the scroll case and penstock for the 9,000 hp turbine shall be assembled and bolted up to insure that the plates are properly rolled and fitted and drilled for field assembly and riveting.

3-24. PAINTING. All exposed unfinished surfaces of the turbines and accessories that are not to be in contact with water shall be given one shop coat of pure red-lead and linseed oil point prior to shipment. All such surfaces that will be in contact with water shall be given a shop coat of bituminous paint, similar and at least equal to Reilly Tar and Chemical Corp. bituminous paint No. CA-40. Where welded construction is used for the plate-steel turbine pit and draft tube liners, a band 4 inches wide from the field weld shall be left unpainted on the inside of the plate. All surfaces shall be thoroughly cleaned before painting. All finished surfaces shall be coated with a suitable rust-preventative compound. All surfaces which will be embedded in concrete shall be cleaned and left unpainted. All surfaces subject to contact with lubricating or governor oil shall be clean and free from rust, but not painted. All painting after erection will be done by the Government.

3-25. SERVICES OF ERECTING ENGINEERS AND SUPERVISING MASTER MECHANIC. The turbine contractor for each schedule shall furnish one or more competent erecting engineers, as requested by the contracting officer, to supervise the erection, starting and operation of the apparatus until the field tests are completed; the turbine contractor shall be responsible for the proper erection of the apparatus. The Government may also require the turbine contractor for each schedule to furnish a supervising master mechanic skilled in various trades to assist the erecting engineers in the foregoing work. The erecting engineers and supervising master mechanic shall report for duty at such time as required by the contracting officer and shall remain on duty until the completion of erection and the satisfactory completion of all tests or until released by the contracting officer. These men will be subject to call at any time but will normally not be required to work more than 8 hours in any one day. However, in an emergency, these men will render such services as are required of them for such longer periods per day as are determined by the contracting officer to be necessary to serve the best interests of the United States. For the services of such erecting engineers and supervising master mechanic, the turbine contractor will be paid the amounts per man-day, including Sundays and national legal holidays, stated in the contract for each erecting engineer and supervising master mechanic. The payment shall cover the entire period of time that the erecting engineers and supervising master mechanic are in the service of the Government exclusive of the time spent traveling from the home station to Massena, New York, and return. The cost of transportation of the erecting engineers and of the supervising master mechanic shall be borne by the turbine contractor.

SECTION IV.

GOVERNOR EQUIPMENT

4-01. GENERAL. The governing equipment for each pair of 67,100 hp turbines hereinbefore specified shall be the Woodward Governor Company's cabinet actuator type or equal, arranged in "Twin System". The actuators for two turbines will be placed in line within several feet of each other, with the intervening space occupied by the electric control board for the units, and the assembly located midway between the pair of generators. The governor and switchboard contractors shall cooperate to secure uniform appearance for the entire front of actuators and control boards. The necessary pumps, valves, gages and controls for the oil-pumping system shall be mounted together on a common sump base large enough to hold all of the oil in the twin system and enclosed in a cabinet, to be located on the floor at elevation 179.0.

The governing equipment for the 9,000 hp turbine shall be a single Woodward Governor Company cabinet actuator type or equal.

The governing equipment for each turbine shall also include permanent magnet generator, pressure tank, all piping and fittings, restoring mechanisms and all the necessary parts and accessories required to make a complete unit for regulating the speed and controlling the gate operation of the turbine with which it is to be used, except those parts specifically exempted herein.

The governing system for each size turbine shall be designed to operate at a maximum working pressure of 300 lbs. per square inch, and shall be guaranteed to safely withstand 450 lbs. per square inch test pressure. The system shall have adequate capacity to supply the necessary quantity of oil to the servo-motors to operate the turbine gates from closed to full open or vice versa in five (5) seconds at maximum operating head with a minimum pressure of 250 lbs. per square inch.

4-02. ACTUATOR. The speed responsive element of each actuator shall be driven by an alternating current motor receiving its power supply from a permanent magnet generator driven by the turbine. The speed responsive element shall be anti-friction type and shall be capable of causing the actuator to admit oil to the servo-motors for a corrective movement of the turbine gates in consequence of a speed variation of the turbine of one-fiftieth of one per cent or less beyond the lap of the relay valve as determined by shop tests with pressure gates substituted for servo-motors. The speed of the responsive element shall vary directly with the speed of the main shaft of the turbine for all rates of acceleration and deceleration, including starting.

The actuator cabinet will be located on the generator floor, elevation 197.5, and shall be totally enclosed. All of the necessary valves to control the oil for the actuating mechanism shall be of the hydraulically operated type, incorporated as an integral part of the actuator unit and shall be controlled by a manually operated pilot valve mounted on the control panel. All mechanism necessary to permit automatic and manual hydraulic control of the oil pressure to the gate servo-motors shall be included. The relay valve for gate control shall be of the oil pilot operated type.

All electrical control wiring within the actuator shall terminate in suitable terminal blocks, located within the actuator housing and readily accessible by steel doors in the housing. They shall be grouped on one side

of the actuator and sufficient space shall be provided below these terminal blocks and within the housing to accommodate all incoming conduit. All control wiring within the actuator shall be color coded in accordance with Federal Specifications J-C-121. It shall be neatly and properly supported and protected from abrasion where such may occur.

The relay operated oil pilot valve shall be connected in such a way that the operation of the overspeed trip on the main shaft will provide a complete shutdown of the unit after it has reached a pre-determined overspeed in case of failure of the pilot generator or other controls.

The action of the governor in responding to and correcting speed changes shall be practically dead-beat and the governor shall operate without racing or hunting. The governor shall be capable of holding the speed of the unit governed as close as possible to normal when operating at any constant load within the capacity of the turbine, independent of the flywheel effect of the power system to which the unit is connected. The speed droop from no load to full load shall be adjustable from zero (0) upward.

The generators are being purchased with a flywheel effect of 114,000,000 lb. ft.^{2} for the 67,100 hp turbines and 2,200,000 lb. ft.^{2} for the 9,000 hp turbine.

Each governor shall be equipped with means for varying the rate of movement of the turbine gates for a range that may be found desirable under operating conditions, from five (5) seconds per complete stroke upward.

Necessary auxiliaries shall be provided to permit control from the switchboard of the setting of the gate limit, and speed adjustment, and indication of the gate position, gate limit, unit speed and instant of turbine breakaway and final stopping of rotation. All switchboard instruments shall conform in size and finish to other switchboard instruments in accordance with information to be furnished later. All dials, gages, and other instruments or controls mounted on the actuator cabinet shall be designed for flush mounting with flanges.

The front of the actuator shall form a panel, on which the controls and instruments shall be mounted in a harmonious and workmanlike manner. The contractor shall furnish the following controls and instruments and where so specified shall install them on the actuator:

a. A load limit device which can be operated manually at the actuator and also electrically operated by remote control from the switchboard with visual indication of the gate limit setting and gate position at both places.

b. A device for controlling the amount of speed droop, which can be operated manually at the actuator with accurate control and visual indication of the exact settings.

c. A device for controlling the speed of the turbine which can be operated manually at the actuator and also electrically operated direct from the switchboard. The speed control from either position shall be suitable for synchronizing under the full range of operating conditions. A 125 volt D.C. motor with limit switches for use in conjunction with automatic frequency control equipment shall be connected to the speed control through a suitable magnetic or friction clutch.

d. Devices for automatically closing the turbine gates completely, or for closing to speed-no-load position upon operation of any protective devices which may be provided by others such as generator or switchboard contractors.

e. Two electrically operated speed indicators, capable of

indication of instant of turbine break-away and final stopping of rotation, one mounted on the actuator cabinet, and one to be mounted by the Government on the switchboard. A suitable magneto-type generator for use in connection with these speed indicators shall be furnished by the contractor and shall be incorporated in the permanent magnet generator housing.

f. Control of the turbine gates by means of oil pressure from the governor oil-pressure system by hydraulic hand valve for emergencies. The transfer from actuator to hand control and vice versa, shall be as convenient as possible.

g. Pressure gage for indicating, at the actuator, the air pressure in the air receiver.

h. A combination electrical gage to indicate the oil level and pressure in the governor oil pressure tank, to be installed on the actuator, with push button transfer switch.

i. An automatic and manually operated generator air brake valve mechanism, including the following features: Electrical and mechanical interlocks to prevent application of the brakes until the gates are completely closed and the generator breaker is open; equipment for intermittent application of the brake shoes.

j. Five auxiliary switches shall be provided. These switches shall be adjustable for either circuit closing or circuit opening and for any position of the wicket gates, and shall be connected to terminals in the actuator cabinet.

k. Two governor oil pressure failure relays.

4-03. PERMANENT MAGNET GENERATOR. The governor contractor shall provide a permanent magnet generator, to be mounted on top of the pilot exciter by the generator contractor.

An electric tachometer magneto and over-speed switch shall be incorporated as a part of and completely enclosed in the housing of the permanent magnet generator and driven from its shaft.

4-04. PUMPING UNITS.

(a) 67,100 hp Turbines. The pumping unit for the governor of each 67,100 hp turbine shall consist of two motor-driven rotary gear or screw pumps, the main pump to be 50 hp capacity and the small pump of 20 hp capacity, with the pumps for two governing units mounted on a common sump tank base, assembled together with their operating controls in a single cabinet. The operating sequence shall be such that either one or both of the small pumps will handle the necessary oil over periods of minor regulating demand for the two actuators, and one large pump will automatically start whenever the capacity of the small pumps (or single small pump, when one is non-operative) is exceeded. The second large pump shall then automatically start when the oil pressure falls to some predetermined point below that at which the first large pump is set to start.

Provision shall be made for inter-changing the starting periods of the two small pumps and also the starting periods of the two large pumps.

Provision shall, furthermore, be made for parallel operation of the governors, and for interconnection so that either or both of the pumps for one unit may operate with either or both pressure tanks.

Each pump shall be direct-connected to a 550 volt, 3 phase, 60 cycle motor with flexible coupling and shall be furnished with pilot valve, unloading valve, pressure safety valve, pressure pilot switch actuating the starting equipment and so designed and connected as to cause the pump motor

to be started and stopped without load.

The automatic starting equipment shall include relays and contactors for starting low voltage release and over-load protection. The equipment for each pair of governors shall be enclosed in a drip-proof steel cabinet. The cabinets will be mounted apart from other apparatus.

(b) 9,000 HP Turbine. The pumping unit shall consist of one motor-driven rotary gear or screw pump large enough to handle the system, with direct-connected motor, and all other details similar to those specified herein for the pumps for the 67,100 hp turbine.

4-05. PRESSURE AND SUMP TANKS.

(a) 67,100 HP Turbines. The pressure tanks, sump tanks and pumps shall be located on the floor at elevation 179.0. The pressure tank for each governor shall have a capacity of twenty (20) times the servo-motor volume of its unit and shall contain five volumes of oil and fifteen volumes of air at maximum working pressure. The pressure tanks for each pair of governors shall be interconnected. Each pressure tank shall be equipped with sight gages to indicate the oil level in the tank. The gage glasses shall be protected from accidental breakage by suitable guards, and shall be provided with both hand shut-off valves and automatic means for shutting off air or oil discharge in the event of breakage of the gage glass. All connections to the pressure tank except the pressure air inlet, the air blow-off, and the upper gage glass connections shall be made below the low oil level. Provision shall be made so that the oil level cannot fall so low as to admit air from the upper part of the tank into the oil piping system.

The sump tank for each governor shall have sufficient capacity to hold the total quantity of oil in the entire governor system and such additional capacity as will insure adequate and easy separation of entrapped air from oil without undue disturbance. The sump tanks of two governors shall be built together as hereinbefore specified; a valve shall be provided, for manual operation inside the cabinet to permit isolation of either sump tank from the tank of the adjacent unit.

Each sump tank shall be provided with an easily removable strainer through which all oil returned from the servo-motors shall pass. Each sump tank shall also be provided with sight gages for indicating the quantity of oil in the tank and also shall have suitable connections for an oil purifier and a drain connection for draining the tank.

(b) 9,000 hp Turbine. The pressure and sump tanks for the governor of the 9,000 hp turbine shall be of similar details for such equipment for an individual 67,100 hp turbine, as hereinbefore specified.

4-06. PIPING. The contractor shall furnish all necessary oil piping, fittings and valves for the governing system. The piping shall be seamless steel tubing, iron pipe size, and all pressure piping larger than 2-1/2" diameter shall be provided with extra heavy steel Van Stone, or equal, flanges, except the low pressure piping which may be provided with standard cast-iron flanges. Whenever feasible to do so, long radius pipe bends shall be used in lieu of pipe fittings. The entire piping system shall be welded insofar as practicable leaving only such flanged connections as may be necessary for shipment and erection or possible subsequent dismantling for repair. The piping shall be cut to length and fitted with flanges and thoroughly cleaned before shipment. All valves shall be of the rising stem, steel body, bronze mounted

type, except those valves built in and forming an integral part of the governor or pumping unit. All necessary bolts, nuts, washers, gaskets, packing, etc., required in field assembly of the piping shall be furnished.

4-07. RESTORING CONNECTIONS. The restoring connections between the actuators and servo-motors may be either of stiff rods and bell cranks or of the flexible type. If the latter type, the flexible connections shall be mounted on antifriction sheaves and the sheave housings connected by means of seamless steel tubing. After the restoring connections have been assembled permanently in the field, the connection will be filled with grease or heavy oil to make the entire connection self-lubricating.

4-08. WRENCHES, TOOLS, ETC. The contractor shall provide a complete set of any special tools, which may be necessary or convenient for assembling and dismantling the governor. The tools shall be mounted on a neat hardwood board with each item marked for ready identification.

4-09. SHOP ERECTION AND TESTS. Each governor and auxiliary equipment shall be completely assembled in the shop and tested insofar as practicable. Parts subject to oil pressure shall, when practicable, be tested in the shop to fifty percent above the maximum working oil pressure. Various parts will be properly match-marked and dowelled to insure correct assembly and alignment in the field. The entire system subject to governor oil pressure will be tested after erection under a pressure fifty percent above the maximum working oil pressure. The field testing will be done by the Government.

4-10. PAINTING. The interior and exterior surfaces of the pressure tank shall be sand-blasted and coated with enamel or other suitable coating to prevent deterioration of the metal and assure against air leaks.

The actuator cabinet and the cabinet enclosing the pump starting equipment shall be completely painted by the contractor in the shop. They shall be thoroughly cleaned, and given one primer coat, an application of machine filler to fill or patch all holes, pits and defects, a sealer coat of rust inhibitive paint, (being sanded and rubbed smooth after the filler and seal coats), and then finished with two coats of oil-proof machine enamel of color as directed.

All other exposed unfinished surfaces of the governor equipment furnished under these specifications shall be given one shop coat of pure red lead and linseed oil paint prior to shipment. All finished survaces shall be coated with a suitable rust-preventative compound. All surfaces which will be embedded in concrete shall be cleaned and left unpainted. Surfaces subject to contact with governor oil shall be thoroughly cleaned but not painted except as specified for the pressure tank. All painting after erection will be done by others.

4-11. SUPPLY OF OIL. The contractor shall furnish an inital supply of oil for the entire governing system, to be one of the following oils, or other equal and approved:

Texas Company	- Alcaid
Gulf Refining Co.	- Paramount "A"
Pure Oil Company	- Puritan Turbine Oil (Heavy Medium)
Standard Oil of Indiana	- Non-Pareil Turbine Oil

4-12. SERVICES OF ERECTING ENGINEER. The governor contractor shall furnish a competent erecting engineer to supervise the erection, starting and operation of the apparatus until the field tests are completed; and the governor contractor shall be responsible for the proper erection of the apparatus. The erecting engineer shall report for duty at such time as required by the contracting officer and shall remain on duty until the completion of erection and the satisfactory completion of all tests or until released by the contracting officer. He will be subject to call at any time but will normally not be required to work more than 8 hours in any one day. However, in an emergency, he will render such services as are required of him for such longer periods per day as are determined by the contracting officer to be necessary to serve the best interests of the United States. For the services of such erecting engineer, the governor contractor will be paid the amount per man-day, including Sundays and national legal holidays, stated in the contract for erecting engineer for governors. The payment shall cover the entire period of time that the erecting engineer is in the service of the Government exclusive of the time spent traveling from the home station to Massena, New York, and return. The cost of transportation of the erecting engineer shall be borne by the governor contractor.

4-13. ACCEPTANCE TESTS. After installation and beginning of operating the governing equipment will be tested to determine whether the requirements herein specified are met in actual service.

4-14. ARTICLES TO BE FURNISHED BY OTHERS. The Government will furnish the following:

a. Air compressor for supplying air to the pressure tanks.
b. Oil storage tanks, oil filtering system and all piping and fittings incident thereto.
c. Air lines from compressor to pressure tanks.
d. Air lines from actuators to generator air brake cylinders.
e. All external wiring and conduits.

Invitation No._____

STANDARD GOVERNMENT FORM OF BID

(Construction Contract)

(Place)_____

(Date) _____

To: The District Engineer
St. Lawrence River District
U. S. Engineer Office
Massena, New York

In compliance with your invitation for bids dated_____ _____and subject to all the conditions thereof, the undersigned

_____

_____

a corporation organized and existing under the laws of the State of _____hereby proposes to furnish all plant, labor and materials, and perform all work specified in the following schedules, in strict accordance with the specifications, schedules and drawings, for the consideration of the following prices:

SCHEDULE A, - B and - C

67,100 HP TURBINES AND GOVERNORS

The contractor shall furnish all labor, materials,plant and equipment to perform all the work necessary to complete the manufacture of six (6) 67,100 hp Francis type turbines and governors and delivery f.o.b. railroad cars at specified factory shipping point or points, in accordance with the attached specifications for the consideration of unit prices as follows:

Item No.	Unit	Description	Unit Price	Quantity	Amount
1	Lump Sum	67,100 hp turbines and governors		6	$_____
2	1 Model Test	Additional model tests	$_____	2	$_____
3	Man Day	Erecting Engineer	$_____	1,000	$_____
4	Man Day	Supervising master mechanic	$_____	1,000	$_____
					$_____

	Amount
Amount to be deducted from bid price if boring apparatus and tools will not be required to be furnished.	$_____

The bidder shall fill in all blank spaces.

The bidder may qualify his bids on all schedules as follows:

If bid on this schedule is accepted, bid on schedules_____ cannot be accepted.

SCHEDULE D

9,000 HP TURBINE AND GOVERNOR

The contractor shall furnish all labor, materials, plant and equipment to perform all the work necessary to complete the manufacture of one (1) 9,000 hp Francis type turbine and governor and delivery f.o.b. railroad cars at specified factory shipping point or points, in accordance with the attached specifications for the consideration of unit prices as follows:

Item No.	Unit	Description	Unit Price	Quantity	Amount
1	Lump Sum	9,000 hp turbine and governor	$_____	1	$_____
2	1 Model Test	Additional model tests	$_____	2	$_____
3	Man Day	Erecting engineer	$_____	80	$_____
4	Man Day	Supervising master mechanic	$_____	80	$_____
					$_____

The bidder shall fill in all blank spaces.

The bidder may qualify his bids on all schedules as follows:
If bid on this schedule is accepted, bid on schedules_____ cannot be accepted.

Note: All amounts and totals given above will be subject to verification by the United States. In case of variation between unit bid prices and amounts and totals stated by bidder, the unit prices will be considered to be his bid.

Each bidder shall submit with his bid the following data:

	67,100 hp Turbine	9,000 hp Turbine
Expected performance curves from half to full load, at net heads of	73, 77, 81 and 85 ft.	73, 81 and 85 ft.

EXPERIENCE DATA

(See Invitation for Bids)

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

It is hereby warranted that in the event award is made to the undersigned there will be used in the performance of the work covered by the contract only such unmanufactured articles, materials and supplies as have been mined or produced in the United States, and only such manufactured articles, materials and supplies as have been manufactured in the United States all from articles, materials, or supplies mined, produced or manufactured, as the case may be, in the United States except as noted below or otherwise indicated in this bid or authorized in the specifications.

The undersigned agrees, upon receipt of written notice of the acceptance of this bid within 60 days after the date of opening of the bids, to execute the standard form of Government contract (revised September 16, 1935,) in accordance with the bid as accepted, and give performance and payment bonds with good and sufficient surety or sureties for the faithful performance of

the contract, and for the protection of all persons supplying labor and materials in the prosecution of the work, within 10 days after the prescribed forms are presented for signature.

Performance will begin within 10 calendar days after the receipt of the notice to proceed and will be completed as specified in paragraph 1-06 of the specifications.

The data sheets attached hereto will be made a part of the contract. All blank spaces will be filled in by the contractor, and no changes in the sheet as filled in will be allowed after award of contract except upon specific written orders of the contracting officer. One manufacturer only will be specified for each item.

_____ (Witness to Signature)

_____ (Full Name of Bidder)

By: _____

(Corporate Seal)

_____ (Business Address)

Note: Read Standard Government Instructions to Bidders before Preparing this bid.

DATA SHEET

SCHEDULE A, -B and C

The following data applicable to equipment as quoted in Schedule _____ MUST BE FILLED IN BY BIDDER:

Hydraulic thrust at 90 ft. head	_____ lbs.
Runaway speed at 90 ft. head	_____ rpm
Weight of heaviest part	_____ lbs.
Weight of heaviest embedded piece to be handled in substructure construction	_____ lbs.
Weight of rotating parts	_____ lbs.
Weight of complete assembly of turbine shaft, runner, bearing and head cover- for crane lift	_____ lbs.
Total Weight	_____ lbs.
Diameter of shaft (min.)	_____
Diameter of bearing	_____
Length of bearing	_____
Diameter of runner	_____
Diameter of pit liner	_____
Diameter of speed ring	_____
Diameter at top of draft tube	_____
Centerline of distributor to bottom of runner	_____
Governor capacity, required	_____ ft.lbs.
Factory shipping point	_____
Guaranteed Maximum shipping weight	_____ lbs.

_____

_____
(Bidder)

DATA SHEET

SCHEDULE D

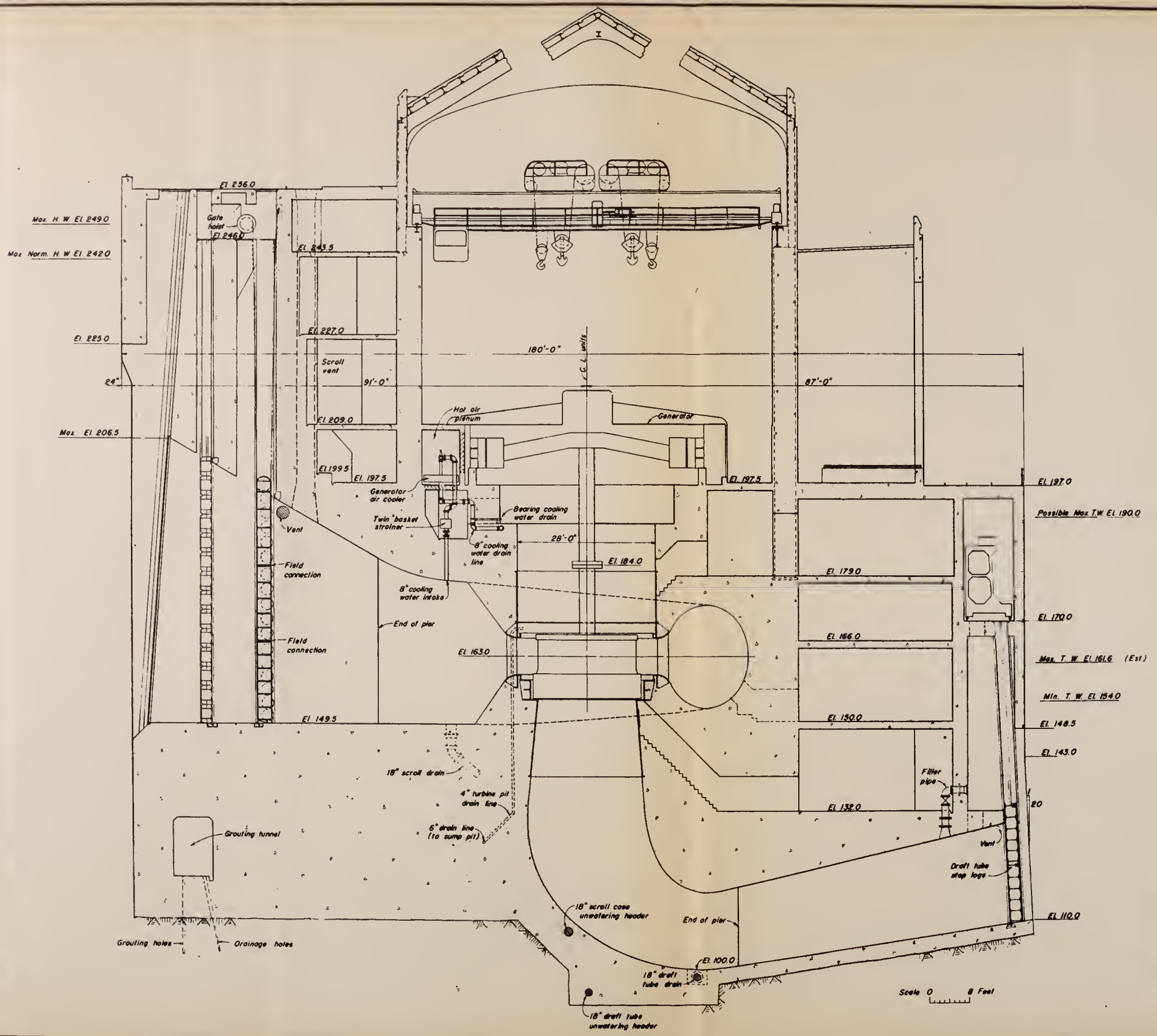
The following data applicable to equipment as quoted in Schedule D MUST BE FILLED IN BY BIDDER:

Hydralic thrust at 90-ft. head	_____lbs.
Runaway speed at 90 ft. head	_____rpm
Weight of heaviest part	_____lbs.
Weight of heaviest embedded piece to be handled in substructure construction	_____lbs.
Weight of rotating parts	_____lbs.
Total Weight	_____lbs.
Diameter of shaft (min.)	_____
Diameter of bearing	_____
Length of bearing	_____
Diameter of runner	_____
Diameter of pit liner	_____
Diameter of speed ring	_____
Diameter of scroll case at transverse center line	_____
Inlet diameter of scroll case	_____
Center line of distributor to bottom of runner	_____
Governor capacity, required	_____ft.lbs.
Factory shipping point	_____
Guaranteed maximum shipping weight	_____lbs.

_____

_____

(Bidder)



ST. LAWRENCE RIVER PROJECT
BARNHART ISLAND POWER DEVELOPMENT
POWER HOUSE
TRANSVERSE SECTION
THRU MAIN UNIT

HARZA ENGINEERING COMPANY ENGINEERS CHICAGO, ILLINOIS	U.S. ENGINEER OFFICE ST. LAWRENCE RIVER DISTRICT MASSENA, NEW YORK
Des. R. Submit'd. Chkd. Dr. 4-8-7 Recom. Chkd. 4-8-7 Approved.	Recommended ..... Head, Engineer Approved ..... Lt. Col. Corps of Engineers, District Engineer
FILE NO. 48C11	SHEET NO. ____ OF ____ SHEETS Transmitted with letter or endorsement dated ____

El. 290.0

El. 262.0

El. 268.0

El. 256.0

Gate hoist

El. 248.0

Max H. W. El. 249.0

Max Norm H. W. El. 242.0

El. 249.5

El. 243.5

Scroll vent

El. 225.0

El. 227.0

187'-0

24"

C. L. Unit

El. 209.0

El. 197.5

Generator air cooler

4" seepage drain line

6" twin basket strainer

Max. El. 180.0

6" cooling water intake

El. 195.0

12'-0"

Grating

Guide bearing

El. 175.0

El. 197.5

El. 182.5

Ramp

El. 174.0

El. 170.0

Possible Max. T.W. El. 190.0

Max. T. W. El. 161.6 (Est.)

Min T. W. El. 154.0

El. 148.5

El. 163.0

El. 156.5

18" scroll drain

El. 150.0

4" turbine pit drain line

6" cooling water drain line

Filler pipe

20

El. 132.0

Grouting tunnel

6" drain header (to sump pit)

El. 110.0

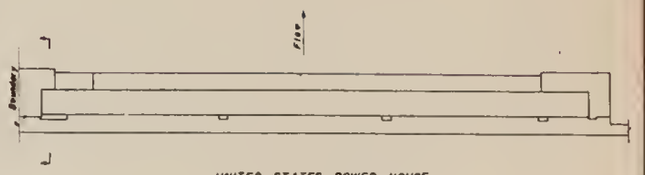
El. 110.0

Grouting holes

Drainage holes

Draft tube drain

Scale 0 6 Feet



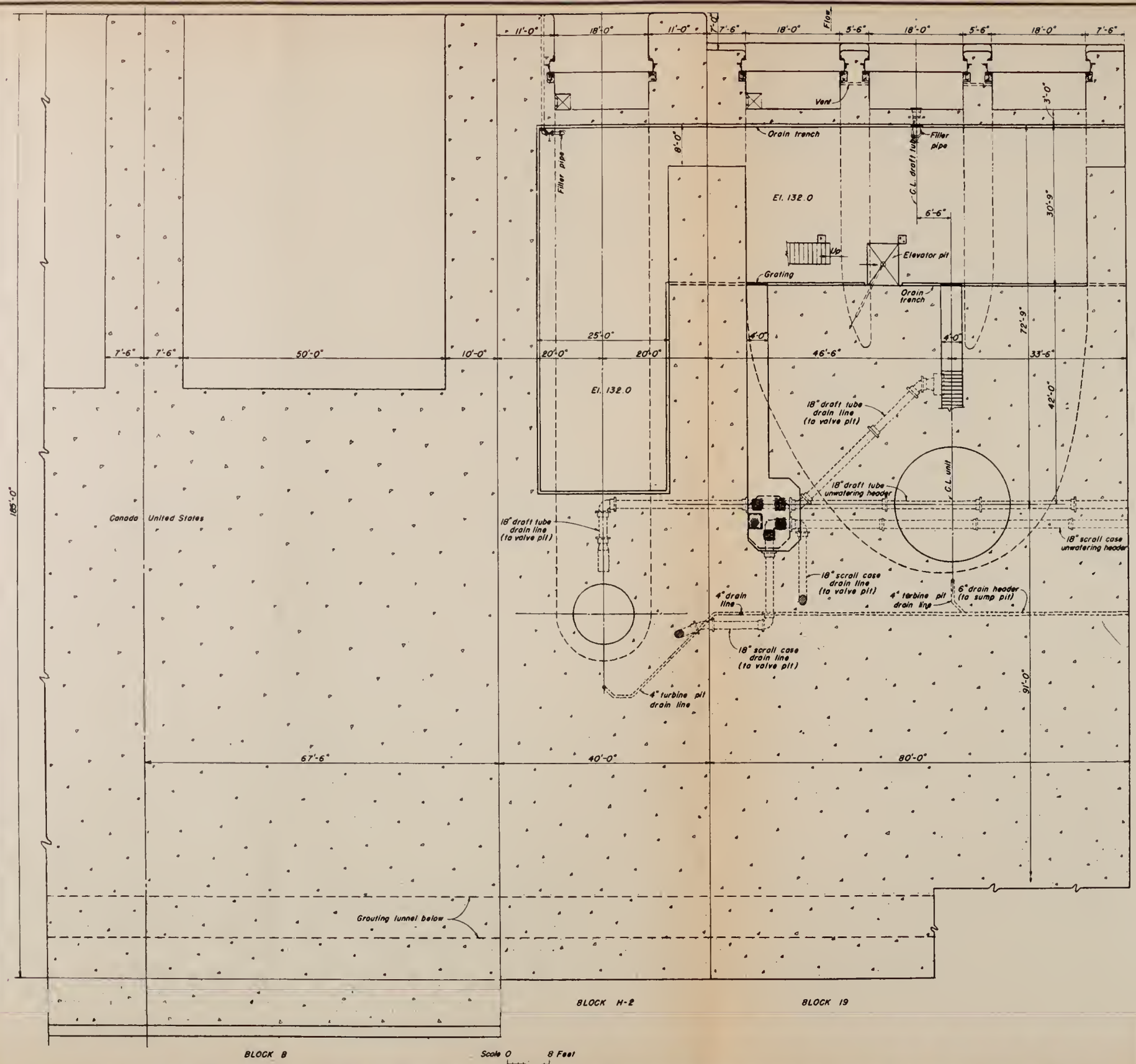
UNITED STATES POWER HOUSE

KEY PLAN

Scale 0 200 Feet

ST. LAWRENCE RIVER PROJECT
BARNHART ISLAND POWER DEVELOPMENT
POWER HOUSE
TRANSVERSE SECTION THRU HOUSE UNIT

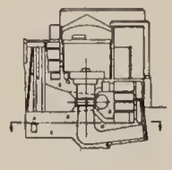
MARZA ENGINEERING COMPANY ENGINEERS CHICAGO, ILLINOIS	U.S. ENGINEER OFFICE ST. LAWRENCE RIVER DISTRICT [redacted]
Des. E. Submit'd ____ Chkd. H.M.M. Recom. ____ Dr. ____ Chkd. H.B.J. Approved ____	Recommended ____ Asst. Engineer. Approved ____ Lt. Col. Corps of Engineers District Engineer
FILE NO. 48015	SHEET NO. ____ OF ____ SHEETS Transmitted with letter or endorsement dated ____ 194



UNITED STATES POWER HOUSE

KEY PLAN

Scale 0 200 Feet

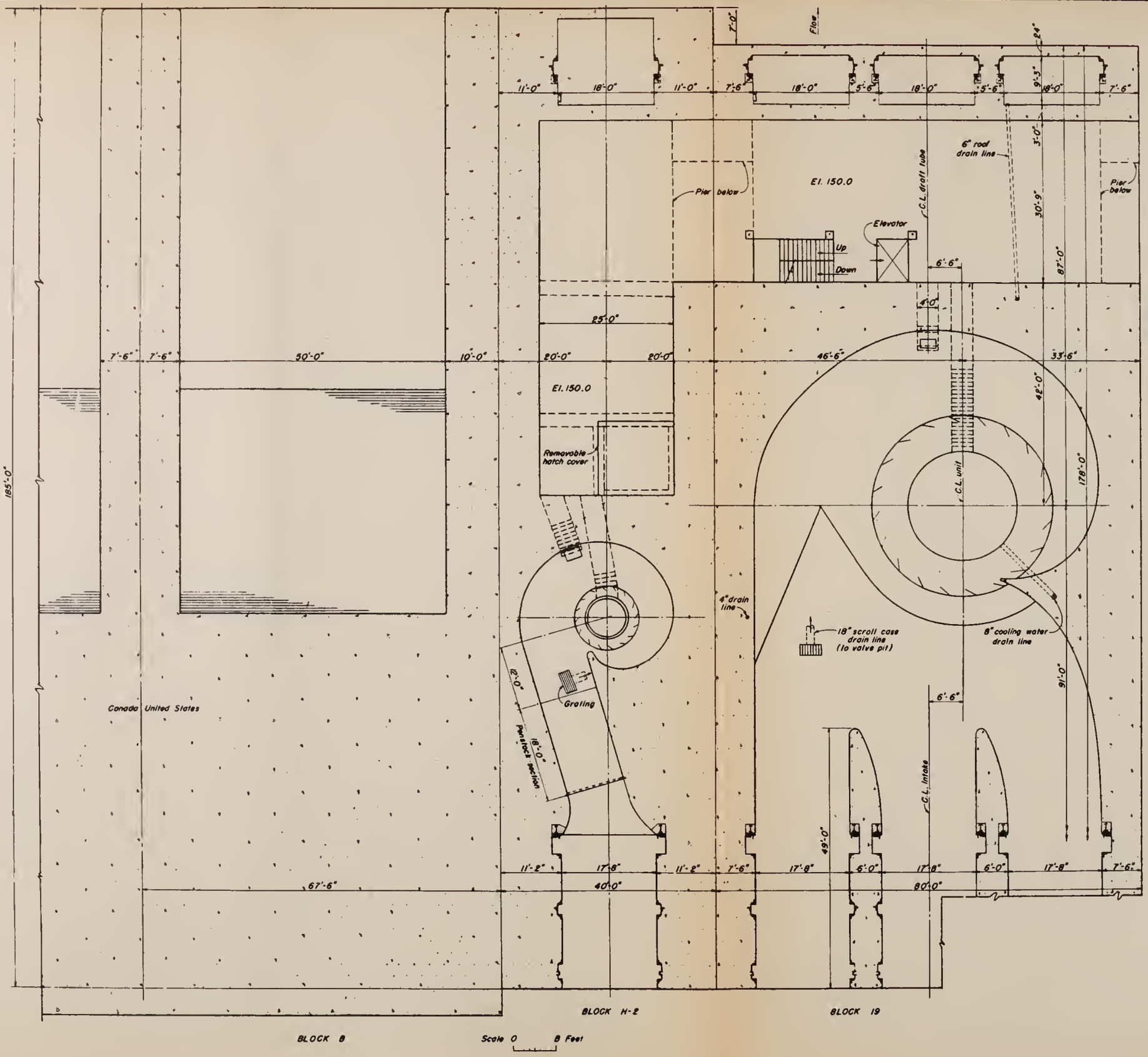


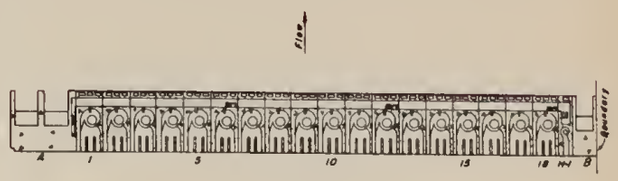
KEY SECTION

Scale 0 100 Feet

ST. LAWRENCE RIVER PROJECT
BARNHART ISLAND POWER DEVELOPMENT
POWER HOUSE
PLAN AT EL. 132.0 FLOOR BLOCKS H-2, 19 AND PART OF B U.S. POWER HOUSE

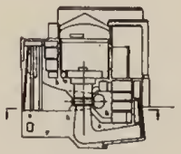
HARZA ENGINEERING COMPANY ENGINEERS CHICAGO, ILLINOIS	U.S. ENGINEER OFFICE ST. LAWRENCE RIVER DISTRICT MASSENA, NEW YORK
Des. JB — Submit'd	Recommended ____ Head Engineer
Chkd — Recom	Approved ____ Lt Col Corps of Engineers District Engineer
Dr. RCT — Approved	
Chkd HH	
FILE NO. 48C25	SHEET NO. ____ OF ____ SHEETS — Transmitted with letter or endorsement dated ____ 194





KEY PLANS

Scale 0 200 Feet



KEY SECTION

Scale 0 100 Feet

ST. LAWRENCE RIVER PROJECT
BARNHART ISLAND POWER DEVELOPMENT
POWER HOUSE
PLAN AT C.L. DIST. AND EL. 150.0 FLOOR BLOCKS H-2, 19 AND PART OF B U.S. POWER HOUSE

HARZA ENGINEERING COMPANY ENGINEERS CHICAGO, ILLINOIS	U.S. ENGINEER OFFICE ST. LAWRENCE RIVER DISTRICT MASSENA, NEW YORK
Des. R.E.T. Chkd. H.P.A. Dr. R.E.T. Chkd. H.P.A. Submitted Recom. Approved	Recommended Approved Lt. Col. Corps of Engineers District Engineer
FILE NO. 48C35	SHEET NO. OF SHEETS Transmitted with letter or endorsement dated 194

PART THREE

BARNHART ISLAND POWERHOUSE

SPECIFICATIONS FOR GENERATORS

Specifications

For

GENERATORS

**

ST. LAWRENCE POWER DEVELOPMENT

Harza Engineering Co.
205 West Wacker Drive
Chicago, Illinois

December 29, 1941

WAR DEPARTMENT
ST. LAWRENCE RIVER DISTRICT

SPECIFICATIONS FOR GENERATORS

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SPECIFICATIONS FOR GENERATORS

SECTION I-GENERAL PROVISIONS

1-01. LOCATION. The Barnhart Island power house is located at the lower end of the International Rapids Section of the St. Lawrence River, about eight miles morth of the village of Massena, New York and four miles west of Cornwall, Canada. The site may be reached by U. S. Highways on the U.S. side of the St. Lawrence River and by Highway No. 2 on the Canadian side.

1-02. WORK TO BE DONE. The work provided for under these specifications is authorized by _____Act, approved _____ _____, 1941.

The work consists of furnishing all plant, superintendence, technical services, labor and materials, except as hereinafter specified, and performing all work required for the design, manufacture, furnishing and erecting the new generators and voltage regulating equipment, complete with accessories, for the Barnhart Island power house, all in accordance with the detailed requirements of these specifications and the following schedules:

Schedule A - Six (6) 55,000 KVA generators
Schedule B - Six (6) 55,000 KVA generators
Schedule C - Six (6) 55,000 KVA generators
Schedule D - One (1) 7,500 KVA generator.

1-03. SHIPMENT. Material and machinery shall be furnished and delivered f.o.b. railroad cars factory shipping point and will be shipped on Government bills of lading furnished by the contracting officer. The contractor shall prepare all materials and articles for shipment in such manner as to protect them from damage in transit, and shall be responsible for and make good any and all damage due to improper preparation or loading for shipment. Where necessary, heavy parts or machines shall be mounted on skids or crated, and any articles or materials that might otherwise be lost shall be boxed or wired in bundles and plainly marked for identification. All material shall be so loaded that it will not shift or become damaged during hauling. All parts exceeding 200 pounds gross weight shall be prepared for shipment so that slings for handling by crane from the car in the power house may be readily attached while the parts are on the car. Boxed parts, where it is unsafe to attach slings to the box, shall be packed with slings attached to the part, the slings to project through the box or crates so that attachment to the hoisting equipment can be readily made.

As soon as each shipment is made, the contractor shall furnish shipping notices on which shall be shown, in addition to the usual data, a description of the article furnished and the item number of the contract schedule to which the article applies; also the shipping weight of each item. The total shipping weight shown on the shipping notice shall correspond to the total weight shown on the bill of lading.

It is understood and agreed that, if the actual shipping weight as later determined by the freight bills, exceeds the shipping weight stated by the bidder in his bid, the Government will deduct from any payment due the contractor the cost of transportation from the shipping point to Massena, New York, on such excess weight. Excess weight shall be defined as that in excess of the estimated weight given by the bidder in his bid. Where shipments are in fact made from points other than those stipulated in the contract or, at the option of the contracting officer, where excess weight is involved, an amount sufficient

to cover any excess in freight costs to the Government will be withheld from final payment and vouchered to the General Accounting Office for direct settlement.

The Government will be responsible for placing the cars containing this equipment and material within the power house where they can be reached with the power house cranes. This contractor shall unload, store, unpack and erect the generators, their exciters, housing and air coolers, complete, ready for connection of external electrical connections and piping, and shall conduct all specified tests. For these tests the Government will furnish, free of charge, the required circuit breakers and any other equipment which may be available and suitable for use during the tests, but this contractor shall furnish all other instruments, transformers, temporary wiring, etc. required for this purpose.

1-04. DRAWINGS. The following drawings, showing the general location arrangement and dimensions of the power plant, accompany and form a part of these specifications. A complete set of drawings of the power house is filed in the United States Engineer Office, St. Lawrence River District, Massena, New york, where they may be inspected by interested parties:

TITLE	FILE MARK
Transverse Section Through Main Unit	48C11
Transverse Section Through House Unit	48C15
Plan at El. 197.5 Blocks 36 & C U. S. Power House	48C56
Proposed Generator Housing	48E7

1-05. DRAWINGS AND DATA TO BE FURNISHED BY THE CONTRACTOR. The contractor shall, within 60 calendar days after notice to proceed with the work, submit for the approval of the contracting officer, assembly and detailed drawings and data, of parts affecting the machine foundations and power house structure. This shall include, but shall not be restricted to, the location and size of all wires, pipes, terminal blocks, etc. to which external connections are to be made by others; location and size of all anchor bolts and sole plates, and all loads including those due to short circuit stresses, on each sole plate; overall dimensions of rotor, shaft, stator with lifting devices and of assembled unit, to permit crane clearance studies and matching of station platform with top and side cover plates; and any similar data or drawings required by the Division Engineer to complete the power house details so far as the same are affected by the generator parts.

The contractor shall submit for approval sectional drawings of the complete generator, including a vertical section through the unit, a horizontal plan of the top of the unit and of the bearing bracket and such additional assembly and sub-assembly and detailed drawings as are required to fully demonstrate that all parts of the appratus to be furnished will conform with provisions and intent of the specifications.

To facilitate approval of drawings, two prints with the original carrying letter and a copy thereof shall be submitted to the contracting officer, and two prints with a copy of the carrying letter shall be forwarded to

(Details of routing of prints of shop drawings
to be inserted by U. S. Engineer Office)

Decision on these drawings, either approval or disapproval, will be given by the contracting officer by letter or telegram within fifteen calendar days after receipt of drawings by the contracting officer. In the event that action on drawings is not taken within fifteen calendar days, the time for completion of the contract will be extended as provided in paragraph 1-06. The same number of copies shall be re-submitted in the same way for approval for any drawing returned by the contracting officer for correction.

After final approval of any drawing, six additional prints of that drawing shall be forwarded to the contracting officer.

All drawings submitted for approval, except the contractor's standard drawings or detail sheets, shall be on sheets of the standard dimensions of the United States Engineer Department (27" x 42" overall with 2" trim marginon the left side and 1/2" trim margin on other sides.) Each shall be provided with a blank white space, approximately 3 by 4 inches, near the lower right corner specifically indicated to be used for notations by the contracting officer. All of these drawings will form a part of the contract. All of the applicable requirements of this paragraph it reference to drawings to be prepared by the contractor shall apply equally to catalog cuts, illustrations, printed specifications or other data submitted for approval, except that where specifically indicated in the detailed specifications that a smaller number than twelve (total) will meet the requirements of the Government, such lesser number may be furnished.

Any construction work done prior to the approval of drawings will be at the contractor's risk. The contracting officer shall have the right to require the contractor to make any changes in the designs which in his opinion are necessary to make the apparatus conform to the provisions and intent of these specifications, without additional cost to the Government. Approval by the contracting officer of the contractor's drawings shall not be held to relieve the contractor of any part of the contractor's obligation to meet all of the requirements of these specifications or of the responsibility for the correctness of the contractor's drawings. Upon completion of the work under this contract, the contractor shall furnish a complete set of process tracings together with two complete sets of blueprints of all drawings, as finally approved, and four copies of operating instructions and parts catalogs. These tracings and drawings shall show all changes and revisions made up to the time that the apparatus is completed and accepted.

Parts catalogs and operating instructions, especially prepared covering all equipment furnished under this contract, which may be needed or useful in operation, maintenance, repairs, disassembly or re-assembly, and for repair and identification of parts for ordering replacements, s hall be assembled under a suitable common cover.

The contractor shall also furnish the following computed data, in quadruplicate, regarding the electrical characteristics of the generators:

a. Losses at 25%, 50%, 75% and 100% of KVA rating at rated power factors segregated as follows:
   (1) Friction and windage
   (2) Core
   (3) Armature I squared R
   (4) Stray load

(5) Field I squared R
(6) Main exciter
(7) Pilot exciter
(8) Total losses

b. Resistance of armature and field windings.
c. Deviation factor of wave form.
d. Direct and quadrature axis values of synchronous reactance.
e. Direct-axis, transient reactance.
f. Direct and quadrature axis values of sub-transient reactance.
g. Zero sequence reactance.
h. Negative sequence reactance.

1-06. COMMENCEMENT, PROSECUTION AND COMPLETION. The contractor shall commence work under the contract within 30 calendar days after date of receipt of him of notice to proceed, shall prosecute the said work with faithfulness and energy, and shall complete each generator within the periods of time (calendar days) specified in "Table I."

TABLE 1 - GENERATORS

UNIT NUMBERS, MAIN GENERATORS (55,000 KVA)

SCHEDULE I - - - - No. 36 No. 33 No. 30 No. 27 No. 24 No. 21
SCHEDULE II - - - No. 35 No. 32 No. 29 No. 26 No. 23 No. 20
SCHEDULE III - - - No. 34 No. 31 No. 28 No. 25 No. 22 No. 19
SCHEDULE IV -House Unit (7,500 KVA)

DELIVERY AND ERECTION SCHEDULE
(CALENDAR DAYS AFTER AWARD OF CONTRACT)

ITEM							
Delivery of Material	720	780	840	900	960	1020	720
Completion of Unit Ready for Tests	900	960	1020	1080	1140	1200	780

When conditions at the site of the proposed work are considered by the contracting officer to be unfavorable to its prosecution, the contracting officer may order the contractor, in writing, to suspend the work until reasonable conditions for prosecution of the work obtain. When the work is thus suspended the time for completion of the contract will be extended in an amount equal to the actual number of days of such suspension, as determined by the contracting officer and subject to the provisions of Articles 3 and 9 of the contract.

In case of failure by the United States to furnish uninterrupted service of the facilities to be furnished by the Government and necessary for construction operations, the time for completion of the contract will be extended in an amount equal to the actual number of days that such facilities are out of service.

In the event that decision on approval of drawings is not given by the contracting officer within the 15 calendar day period allowed in paragraph 1-05 hereof, the time for completion of the contract will be

extended in an amount equal to the excess time required for such action.

In case the time for completion of the work is extended due to any of the causes specified herein, it is distinctly understood and agreed that the contractor will accept the extension of time in which to complete his contract in full satisfaction of any delays encountered and the United States will not be held liable for any costs or expenses incurred by contractor as a result of the increased period of the contract.

The contractor shall submit the contracting officer a schedule of shipment of parts to, and a schedule of work to be done at, Barnhart Island, The contracting officer will approve or correct this schedule and will issue shipping instructions and make the necessary arrangements to have space available for the unloading and assembly at the power house site. The contractor shall adhere to this schedule, as approved or as revised from time to time with approval of the contracting officer, and no shipment may be made in advance of schedule without written approval of the contracting officer.

Should the work on the power house be so delayed as to make it impossible to proceed with the generator assembly at the site, according to approved schedule, the Government will provide space at or near the site for storage of all parts until such time as the assembly may proceed and will pay all costs of storing the material and moving it under the power house crane when the building is ready for the assembly.

1-07. SUNDAYS, HOLIDAYS AND NIGHTS. No work shall be done at the site of the power house on Sundays or on days declared by Congress as holidays for per diem employees of the United States except in case of emergency, and then only with the written consent of the contracting officer. Work may be done at night provided the contractor maintains, from sunset to sunrise, such lights on or about his work as the contracting officer may deem necessary for the proper observations and performance of the operations.

1-08. PAYMENTS. Subject to all the provisions set forth below, payments to the contractor will be made monthly in accordance with a well-balanced schedule, to be prepared by the contractor and approved by the contracting officer, apportioning the total amount of the contract among the main items that go to form the completed requirements. The amount apportioned to each of said items shall be separately stated for labor and for material. The total amount shown by said schedule shall equal the total amount to be paid under the contract. In accordance with Article 16 of the contract, 10 per cent of each payment will be retained from that payment. Of the 10 per cent retained one-half, or 5 per cent of the contract price, will be paid when the machinery has been completely installed and tested to the satisfaction of the contracting officer under the provisions of paragraph 1-22, and the remainder will be paid upon final acceptance after 100 days of successful operation and after conducting the overspeed test specified in paragraph 2-23.

1-09. PAYMENT FOR FACILITIES AND SERVICES FURNISHED BY THE GOVERNMENT. Various facilities and services will be furnished the contractor by the

United States free of charge or at the prices indicated herein as provided for in these specifications. The contractor will be billed monthly for all such services furnished at the rates specified herein and all amounts remaining unpaid after twenty days from date of invoice will be deducted from the monthly payments made under this contract to the contractor.

1-10. CONSTRUCTION CAMP. (a) The Government has constructed a camp on the right bank near the plant site and it maintains and operates suitable accommodations to subsist and quarter the contractor's men. The contractor will be required to house as many men in this camp as is deemed practicable as determined by the contracting officer. Charges for subsistence and quarters for men in Government quarters will be the same as charged for Government employees.

The contractor shall pay for quarters and subsistence so furnished monthly within twenty (20) days after receipt by him of invoice, provided that if such payment is not so made, deductions therefor may be made from any amounts due or to become due to the contractor.

(b) RENTAL OF GOVERNMENT BUILDINGS. If at any time during the period of this contract Government owned buildings should not be required for other purposes, they will be made available to the contractor at rental rates to be fixed by the contracting officer. These rates will be based upon amortization of the cost of the buildings during the estimated period of their usefulness in the construction of the power house. Upon request, houses, if available, together with electricity, water, garbage collection and such other facilities as are furnished to Government employees, will be furnished to the contractor as residences for engineers, superintendents, foremen, and other employees who will reside at the work with their families at the same established rates charged Government employees. The contractor shall be responsible for rental and utility charges accruing against any of his employees housed in Government buildings.

(c) FIELD OFFICE. The contractor will be required to locate his main local office and other field offices as may be required for the construction work to be done under these specifications near the site of the work at locations approved by the contracting officer.

(d) TRANSPORTATION OF EMPLOYEES. The contractor shall make arrangements for transportation of his men between the camp and the site of the work without charge to the employees.

1-11. DAMAGE. Damage to Government property or buildings occupied by the contractor by fire, tornado, or any other causes shall be made good by him without expense to the United States, except as stated there in after in this paragraph. All loss or deterioration of, or damage to the permanent equipment supplied by the contractor by flood, accident or exposure prior to final acceptance shall be made good by the contractor without expense to the United States. He will also be held reaponsible for any damage done to adjoining property through his neglect or failure to protect the work properly. He will be held responsible for damage done to the power house only as results from his neglect or failure to protect the work properly.

1-12. ELECTRICAL ENERGY.

1-13. CONSTRUCTION RAILWAY.

1-14. HIGHWAYS.

1-15. HOSPITAL AND MEDICAL CARE.
1-16. TELEPHONE SERVICE.
1-17. WATER SUPPLY.
1-18. FIRE PROTECTION SYSTEM.
1-19. HEAT.
1-20. PURCHASE ORDERS.
1-21. INSURANCE.
1-22. PHOTOGRAPHS.

(These paragraphs are to be U. S. Engineer Office standard paragraphs for such items)

1-23. DELIVERY AND SHIPMENT. Material and machinery furnished under the contract to which the United States acquires title shall be delivered f. o. b. railroad cars at specified factory shipping point and will be shipped on Government bills of lading furnished by the contracting officer. The contractor shall prepare and load all materials and articles for shipment in such manner as to protect them from damage in transit, and shall be responsible for and make good any and all damage due to improper preparation or loading for shipment. Except as otherwise provided in Paragraph 1-06, the contractor shall unload and handle all materials and machinery from cars at point of destination.

It is understood and agreed that, if the actual shipping weight as latter determined by the freight bills, exceeds the shipping weight stated by the bidder in his bid, the Government will deduct from any payment due the contractor the cost of transportation from the shipping point to Massena, New York, on such excess weight. Excess weight shall be defined as that in excess of the estimated weight given by the bidder in his bid. Where shipments are in fact made from points other than those stipulated in the contract or, at the option of the contracting officer, where excess weight is involved, an amount sufficient to cover any excess in freight costs to the Government will be withheld from final payment and vouchered to the General Accounting Office for direct settlement.

In order to prevent congestion due to several contractors erecting turbines, generators, etc. simultaneously, the contractor shall cooperate with the contracting officer in the preparation of shipping schedules as the work progresses, and no shipmints of materials on their contract shall be made without the approval of the contracting engineer.

1-24. INTENT OF PLANS AND SPECIFICATIONS. The intent is to prescribe a complete work or improvement which the contractor shall do in full compliance with the plans and these specifications. The contractor shall perform the work in accordance with the lines, grades, typical cross sections and dimensions shown on the plans or as modified by written orders involving changes or imposed as a result of changed conditions; and he shall furnish, unless otherwise provided in the specifications, plans, or in the contract, all mateials, implements, machinery, equipment, tools, supplies and labor necessary for the prosecution of the work.

1-25. INTERPRETATION OF SPECIFICATIONS. On all questions relating to the acceptability of material or supplies of machinery, classifications of materials, the proper execution of the work, and the interpretation of the specifications, the decision of the contracting officer shall

be final, subject to appeal as provided in paragraph 1-39 hereof.

1-26. MATERIALS AND WORKMANSHIP. All materials shall be the best of their respective kinds and of the classification and grades designated. Material shall, as far as practicable, conform to the latest specifications issued by the Federal Specification Board covering the class or kind of materials to be used. All materials, supplies and articles furnished shall, wherever so specified, and otherwise wherever practicable, be the standard stock products of recognized, reputable manufacturers. The standard stock products of manufacturers other than those specified will be accepted when it is proved to the satisfaction of the contracting officer, in accordance with Article 7 of the contract that they are equal in strength, durability, usefulness and convenience for the purpose intended.

In accordance with Article 7 of the contract, all materials shall be of the highest grade, free from defects and imperfections, of recent manufacture, and unused. Workmanship shall be of the highest grade and in accordance with the best modern standard practice.

1-27. WORK COVERED BY CONTRACT PRICE. The contract price for each item of the schedule shall include the entire cost to the United States for that item in place when finally accepted, unless otherwise specifically provided for herein.

1-28. PROGRESS, ORGANIZATION AND PLANT. The contractor shall employ an ample force of men and provide construction plant properly adapted to the work and of sufficient capacity and efficiency to accomplish the work in a workmanlike manner at a rate of progress satisfactory to the contracting officer. All his plant shall be maintained in good working order and provision shall be made for immediate emergency repairs.

Should the contractor fail to maintain a satisfactory rate of progress, the contracting officer may require that additional men or plant be placed on the work, or a re-organization of plant layout be effected in order that the work be brought up to schedule and maintained there. Should the contractor refuse or neglect to so increase the number of men or plant, or reorganize the plant layout in the manner satisfactory to the contracting officer, the latter will proceed under the provisions of Article 9 of the contract.

1-29. ORDER OF WORK. The work is to be carried on at such localities and in such order of precedence as may be found necessary by the contracting officer.

1-30. MISPLACED MATERIAL. Any material that is placed elsewhere than in places designated or approved by the contracting officer will not be paid for, and the contractor may be required to remove such material and place it where directed.

1-31. COOPERATION WITH OTHER CONTRACTORS. During the life of this contract other work will be in progress, conducted by the Government and other contractors for the construction of other parts of the Barnhart Island project. The contractor shall so arrange his work and plant as to reasonably cooperate, in the opinion of the contracting officer, with the forces of the Government and other contractors engaged in constructing

other features of the project. No allowance for damages or extra compensation on account of cooperation required, will be made.

The erection space within the power house is shown on the drawing. The floor in this space is designed for a loading of 1000 pounds per square foot. This space will be available for the work under this and other contracts for turbines and generators, but the contractor will be required to schedule his work with the contracting officer and to arrange for assembly of such portions of his generators and equipment as cannot be accommodated in the regular erection bay. For this purpose, the contractor will be permitted to use such turbine and generator foundation spaces as are not otherwise occupied and as may be assigned to him by the contracting officer.

The contractor on schedule I shall furnish two floor plates for placing generator rotors in the erection bays on the United Stated side of the International Boundary Line. Each generator contractor shall furnish two pedestals for the support of his rotors, and all contractors will be required to cooperate in the design of the pedestals to the end that all pedestals will fit these two floor plates.

Each half of the generator room will be equipped with two cranes each of 300 ton capacity and each with auxiliary hoists and provision will be made for simultaneous use of these two cranes with lifting beams for such lifts as require this crane combination. In addition to the generator room cranes, there will be one 200 ton crane over the erection bay on the downstream side of the generator room in each end of the power house and one in the erection bay at the International Boundary Line. These will be available for unloading parts from railway cars and provision will be made to transfer these parts under the generator room cranes. Crane operators will be furnished by the Government. The Government will also furnish a sufficient number of power operated trucks capable of hauling loads not exceeding two tons and will furnish operators for these trucks. All material within their capacity will be hauled by these trucks and will be placed within reach of any gib cranes, derricks or hoists that the contractor may furnish for his erection work. All labor, other than the operators, in connection with delivery of his parts by crane or by truck shall be furnished by the contractor. Use of these cranes and trucks will be scheduled by the contracting officer and every reasonable effort will be made to expedite the work of all concerned but no additional payment will be made to any contractor because of delay caused by this scheduling.

1-32. INSPECTION AND TESTS.

1-33. BASIS FOR EQUITABLE ADJUSTMENTS FOR ADDITIONAL WORK REQUIRED BY CHANGES IN DRAWINGS AND SPECIFICATIONS.

1-34. ADJUSTMENT OF PRICES FOR LABOR AND MATERIAL.

1-35. COST DATA TO BE FURNISHED BY THE CONTRACTOR.

1-36. IDENTIFICATION OF CONTRACTOR'S EMPLOYEES.

1-37. CLEANING UP.

1-38. FINAL EXAMINATION AND ACCEPTANCE.

1-39. PROTESTS AND APPEALS.

1-40. LIABILITY AND SAFETY REQUIREMENTS AT THE SITE OF THE PROJECT.

1-41. PATENTS.

1-42. PREFERENCE FOR DOMESTIC ARTICLES.

1-43. REPORTS.

1-44. RATE OF WAGES.

1-45. TAXES.

1-46. FEDERAL SPECIFICATIONS.

1-47. EXECUTION OF CONTRACT.

1-48. APPROVAL.

(These paragraphs are to be U. S. Engineer Office standard paragraphs for such items.)

SECTION II - DETAIL SPECIFICATIONS
GENERATORS

2-01 REQUIREMENT. It is required that there be furnished f.o.b. manufacturer's shops and unloaded, erected and tested in the Barnhart Island power house on the St. Lawrence River near Massena, New York, the following equipment for the United States Government:

Eighteen (18) 55,000 kva, 60 cycle, 3 phase, 13,800 volt, 69.2r.p.m., 95% power factor generators, each of the vertical shaft type and each with direct connected main exciter and pilot exciter, thrust and guide bearings, air coolers, voltage regulators, rheostats and field breaker panel.

One (1) house service unit, 7500kva, 60 cycle, 3 phase, 13,800 volt, 150 r.p. m., 85% power factor generator of the vertical shaft, umbrella or overhung type with direct connected exciter, thrust and guide bearings, air coolers, field rheostat and field breaker panel.

2-02. WORK AND MATERIALS TO BE FURNISHED BY THE GOVERNMENT. The Government will, without cost to the contractor, furnish and provide the following:

a. All concrete foundations for supporting the generators and auxiliary equipment. (The contractor, however, shall furnish anchor bolts and any other parts which are to be embedded in the concrete foundations for the generators and drawings in sufficient detail to permit the proper placing of these bolts and parts by others.)
b. Transportation as specified in paragraph 1-03.
c. Use of crane facilities including crane operators at the contractor's sole risk as may be necessary for the assembly and erection of the apparatus in the power house. The use of crane facilities must be shared with other contractors and the Government as directed by the contracting officer.
d. Electrical energy as specified in paragraph 1-12.
e. All permanent electrical conduits and electrical connections external to the generators.
f. All necessary permanent piping, external to the generators, for water and air.
g. Space in the assembly bay and on portions of the generator room floor sufficient for the assembly of two generators and any additional space as may be available. (See paragraph 1-31).
h. Painting of all apparatus after installation is completed.
i. Use of hydraulic turbine, switching apparatus and such other facilities as the Government has available for preliminary operation of the generator and for making field acceptance tests on the generator and auxiliary equipment.
j. Load for heat run as required under paragraph 2-22.
k. Circuit breaker suitable for short circuit tests.

2-03. WORK AND MATERIALS TO BE FURNISHED BY THE CONTRACTOR. Except as otherwise provided in paragraph 1-02, the contractor shall furnish all labor, materials, equipment, instruments, tools and special facilities re-

quired in connection with the manufacture, installation and testing of the generators and auxillary apparatus and shall provide for or arrange for such temporary construction, and other facilities as he may require in connection with erection of his equipment. The contractor shall furnish a device or devices for attaching the rotors and shafts and any other parts as necessary to the crane lifting beams, and shall cooperate with the crane contractor in fitting these devices to the beams.

2-04. ELECTRIC WELDING - FUSION TYPE.

(a) Preparation for Welding. Members to be joined by welding shall be cut accurately to size and, where required, shall be rolled or pressed to the proper curvature in accordance with dimensions shown on the drawings. The edges of the members shall be sheared, flame-cut, or machined to suit the required type of welding and to allow thorough penetration. The cut surfaces shall expose sound metal free from laminations, surface defects caused by shearing or flame-cutting operations, or other injurious defects. The surfaces of plates to be welded shall be free from rust, grease and other foreign matter for a distance of at least one-half of an inch back from the edge of the weld.

(b) Welding. All welding shall be performed by the electric-arc method, by a process which will exclude the atmosphere from the molten metal and, where practical, under procedure control using automatic machines. After being deposited, welds shall be cleaned of slag and shall show uniform sections, smoothness of weld metal, feather-edges without overlap, and freedom from porosity and clinkers. Visual inspection at the edges and ends of welds shall indicate good fusion with the base metal. Particular care shall be taken in aligning and separating the edges of members to be joined by butt-welding, so that complete penetration and fusion at the bottom of the joint will be assured. All pinholes, cracks, and other defects shall be repaired by chipping or grinding the defects to sound metal and rewelding. Where fillet welds are used, the members shall fit closely and shall be held together during welding. The welding rods used for manual welding shall be of the heavily coated type and shall be suitable for all-position welding where required.

(c) Qualification of Welding Process. The contractor shall have established and recorded a process specification of the welding process that he proposes to use and, if required, shall furnish to the contracting officer a copy of such process specification, together with certified copies of reports of results of tests made in accordance with the process specification. The qualification of the welding process shall be in accordance with the "Standard Qualification Procedure" of the American Welding Society, and the minimum requirements of the tests shall be as stated in the appendix to said "Standard Qualification Procedure."

(d) Qualification of Welders. The contractor shall be responsible for the quality of the work performed by his welding organization. All welding operators assigned to the work shall have passed the qualification test for welding operators as specified in the "Standard Qualification Procedure" of the American Welding Society, and the minimum requirements of the tests shall be as stated in the appendix to the above-mentioned rules. If at any time, in the opinion of the contracting officer, the work of any operator appears questionable, such operator will be required to pass additional qualification tests determined by the contracting officer. All qualification tests for welding operators and the physical tests of the welded specimens shall be made in the presence of the inspector. The contractor shall furnish all test plates and all welding electrodes required for making the qualification tests. The test plates shall be of the same material as the

material to be used in the work, the edges shall be grooved or beveled where required, and the technique of welding shall be the same as to be used in the work. The welding electrodes shall be of the same size, type, and brand of manufacture as those to be used in the work. If required, the contractor shall furnish to the contracting officer certified copies of reports of the result of physical tests of specimens welded in the qualification tests. All expense in connection with making the qualification tests for welding operators shall be born by the contractor.

2-05. TEST SPECIMENS. The contractor shall provide without charge to the Government, all necessary test specimens properly machined for testing and all samples or drillings for analysis, and shall notify the contracting officer or his representative when the test specimens or samples are ready for testing. All test specimens and samples shall be plainly marked to indicate the materials they represent and shall be properly boxed and prepared for shipment if desired. All tests including materials shall be made at the expense of the contractor. Acceptance of apparatus or the waiving of inspection thereof shall in no way relieve the contractor of the responsibility for furnishing apparatus meeting the requirements of these specifications.

2-06. GENERAL DATA. Each generator will be wye connected with the neural leads brought out for differential protection and grounding. Each main unit shall have main and pilot exciters with nominal voltage of 250 volts and provisions for mounting a permanent magnet generator for driving the governor. The house service unit shall be of the same type except that no pilot exciter will be required. Rotation of all units will be clockwise when viewed from above. The main requirements for each of the generators will be as follows:

	18 Main Units	1 House Service Unit
Kva rating	55,000	7,500
Power factor	.95	.85
Frequency, cycles	60	60
Number of phases	3	3
R.P.M.	69.2	150
Phase to phase volts	13,800	13,800
Insulation Class	B	B
WR^2 not less than		2,200,000
Turbine and hydraulic thrust load - lbs.		
Runaway speed - r.p.m.		

Ratings, tests, characteristics, etc. shall be in accordance with the latest adopted standards of the A. S. A. and of the National Electrical Manufacturers' Association, each as they apply, unless otherwise definitely specified. The maximum temperature rise of the alternator armature and field windings shall not exceed (60) degrees Centigrade with full load at rated speed, voltage, and power factor and with entering air not more than 40 degrees Centigrade.

2-07. ELECTRICAL CHARACTERISTICS. The electrical characteristics shall

be standard and approximately as follows:

	18 Main Units	1 House Service Unit
Transient reactance	.44	.44
Short circuit ratio	1.15	1.05
No-load balance telephone interference factor, not greater than	50	60
No-load residual telephone interference factor, not greater than	30	30
Deviation factor of wave form shall not exceed	10%	10%
Efficiency at 75% load and at rated speed, power factor, and voltage shall not be less than	96	

All main generators shall be capable of successful parallel operation with each other on a common low tension bus.

2-08. STRUCTURAL DETAILS. The maximum unit stresses due to maximum (runaway) speed shall not exceed two thirds of the yield point.

The generators shall be designed and constructed so that they can be assembled and disassembled with the power house cranes without disturbing any other unit.

Each generator shall be provided with a metal base plate or plates and with bolts and dowels for fastening the stator frame and bearing bracket to the base plates and for preserving the alignment between the generator parts and base plates. Anchor bolts and dowels shall be supplied for the stator sufficient to prevent movement of the stator under the short circuit conditions specified in paragraph 2-22-j. A very liberal number of dowels shall be provided in order to prevent any possible movement of the bearing bracket on the base. The bracket supporting the thrust bearing shall be of sufficient strength and rigidity to support the weight of the entire rotating element of the generator, the turbine runner and shaft and the hydraulic thrust of the turbine runner. The bearing bracket or support shall be so designed and constructed that it can be removed through the stator of the generator. Suitable platforms with safety treads of approved type shall be provided in the exciter housing for the inspection of the exciters. Adequate guards over or around all live or moving parts, including main lead terminals, shall be provided.

2-09. STATOR. The stator core shall be built up with high grade, non-aging, thin laminated silicon steel, each lamination coated on both sides with insulating varnish or other material to minimize eddy current losses. The laminations shall be adequately keyed or dove-tailed to the stator frame, and securely held in place by clamping flanges at each end. To insure uniform tightness of laminations, full final clamping pressure shall be applied to successive layers of laminations not more than 18 inches high while being stacked. There shall be no objectionable buzzing of laminations

during operation. The air ducts in the stator core shall be arranged to make the flow of air smooth and quiet and to minimize air friction losses. The armature winding shall be star connected and both ends of each phase winding shall be brought out of the stator frame at points approved by the contracting officer. Each generator shall be capable of withstanding a 3-phase short circuit at its terminals under operating conditions without injury to the stator winding, provided that the duration of such short circuits is not sufficient to cause injurious heating. The stator winding shall be insulated with full Class B insulation as defined by the A. S. A. Standards. The temperature rise of the stator winding wher delivering full rated output continously shall not exceed sixty (60) degrees Centigrade. The armature coils shall be form wound and interchangeable.

Turn and coil insulation shall be mica or other approved tape continously applied throughout the coils. The coils shall be so impregnated with high-grade insulating varnish that the insulation becomes a dense, homogenous mass, free from air pockets. The insulation shall become reasonably plastic by the application of heat so that the coils can be placed in or removed from the slots without danger of damaging the insulation. The coils shall be treated so as to prevent permanent injury from temporary exposure to dampness. The insulation of the stator coils shall be provided with an outer protective taping of varnished ferrous asbestos cloth or any equivalent semi-conducting material to provide corona shielding. The outer protective taping shall be heat resisting and shall not deteriorate under high temperature.

A type of winding is desired which will minimize circulating current losses and heating. The strands shall be annealed copper, free from splinters, burrs, flaws, rough spots, or sharp corners. In order to insure against shrinkage, the coil-slot wedges shall be of canvas bakelite or other approved materials. The end connections of the coils shall be rigidly supported and braced to prevent vibration and distortion under stresses caused by the most severe short circuit conditions. Twelve 10 ohm resistance temperature detector coils shall be provided in the armature winding of each generator, so located as to indicate as closely as possible the highest temperature obtained in operation. A suitable terminal board mounted on the generator frame in a location to be approved by the contracting officer, and necessary wiring between the terminal board and the individual temperature detectors shall be proved with teach generator. The cable wiring between the terminal board and the temperature recorder will be provided by others.

The contractor shall provide space and means for mounting, within the generator housing, for not more than six current transformers, furnished by others, to be connected in the neutral leads for differential protection of the generators and shall cooperate in this design with the contractor for the switching equipment.

2-10. GENERATOR HOUSING. The generators shall be provided with a housing similar to that indicated on the attached drawing and sufficiently air tight to permit the use of coolers. It is required that the housing and the coolers be so arranged as to permit complete isolation of the unit and re-circulation of the air during the warmer months and to permit "bleeding" of any or all warm air for use in heating the building during the colder months. To this end the contractor will be required to cooperate with all contractors for generators within this plant and to submit the arrangement for the approval of the contracting officer. All fans, partitions within the generator housing, motor operated louvres, motor operated water valves, etc., required for isolated re-circulation of the air shall be included.

All fans and passages required for air circulation throughout the building will be furnished by others. Provision for return of air to the generators may be wholly from below, through the turbine room, or partially from the turbine room and partially from the generator room.

2-11. AIR COOLERS. The contractor shall provide air coolers for each generator. These coolers shall be of the straight tube type with non-ferrous, corrosion-resisting finned tubes expanded into corrosion-resisting tube sheets. The arrangement of tubes shall be such that any tube can be removed and replaced without disturbing any other tube. The water boxes shall be constructed with removable cover plates to permit access to all tubes for cleaning, inspection or replacement without disturbing the water pipe connections. The coolers shall be designed to operate satisfactorily with a pressure of 20 lbs. at the inlet flange and shall be subjected at the factory to a hydrostatic test of 75 lbs. per square inch. The contractor shall provide companion flanges on inlet and outlet pipes. All external pipes and fittings will be furnished and installed by others. Installation of the coolers will be by the generator contractor. For design purposes the temperature of the entering water shall be assumed to be 21 degrees Centigrade. The coolers shall be designed to maintain a temperature of the air entering the generators at not more than forty (40) degrees Centigrade with full load on the generators and with all air re-circulating in the generator and housing. The coolers shall be provided with convenient lifting lugs.

2-12. ROTOR. All WR^2 shall be built into the rotor, no additional flywheel of any kind being permitted.

The pole pieces shall be built of thin laminations secured by rivets or bolts and shall be fastened to the rotor rim by means of accurately machined or die punched dovetails matching similar slots in the rotor rim. Any keys or other devices used to hold the pole pieces shall be firmly locked in place so that no part can work loose or be thrown out. The construction shall be such that the pole pieces may be removed and replaced without lifting the rotor.

The field windings shall be insulated with Class B insulation in accordance with A. S. A. Standards. They shall be such that the temperature rise under any operating conditions shall not exceed sixty (60) degrees Centigrade. The turn insulation shall be thoroughly cemented to the adjacent turns. Insulating collars shall be provided at each end of each field coil and shall be adequately supported at all points. The winding and insulation shall be capable of meeting any mechanical stresses to be imposed thereon by normal or runaway speeds, special care being used to prevent the end turns from deforming or slipping due to centrifugal stress on the interconnections.

On the main generators damper windings shall be provided to improve stability under fault conditions and, specifically, to reduce voltage distortion under conditions of single phase fault. They shall be designed for a ratio of quadrature axis subtransient reactance to direct axis subtransient reactance equal to approximately 1.3. They shall be of low resistance, rugged construction without bolted joints and without connections between the poles. No damper windings will be required on the house service generator.

Collector rings shall be above the main exciter and shall be so spaced and protected by barriers that it will be practically impossible for an operator to cause a short circuit between the collector rings while

changing or adjusting brushes. On the main generators the leads from the collector rings shall run directly to the main exciter armature, as no switch, discharge resistor or rheo-stat is to be used with these generator fields. For the house service generator one main field lead shall be broughtout and back for use with a single pole field circuit breaker.

Slip ring brushes, brush holders, and terminal lugs shall be provided to be used with a Kelvin bridge type of temperature recorder or indicator to be furnished by others. A 100 millivolt shunt shall be mounted in the main field leads. All required wriing shall be installed in conduit from the above to suitable terminal blocks near the generator base at a point approved by the contracting officer.

The rotor of each generator shall be provided with a suitable brake ring with which the brake shoes will make contact. The wearing surfaces of the brake ring shall be made in segments which shall be readily removable and renewable. Adequate provision shall be made for dissipating the heat resulting from the application of the brakes, and to take care of expansion of brake plates.

The contractor shall furnish approved lifting devices for lifting the rotor and for lifting the lower bearing bracket and shaft for each size of generator or one device suitable for all above lifts and shall cooperate with the crane contractor to the extent of securing proper connections between these devices and the crane.

2-13. SHAFT. The generator shaft shall be made of forged openhearth carbon or alloy steel properly heat treated. It shall be of ample size to operate safely at any speed up to and including the specified runaway speed without objectionable vibration or distortion. The generator contractor shall furnish the generator shaft complete to and including half of the coupling matching that on the upper end of the turbine shaft at elevation 184.0 for the main generators and at elevation 195.0 for the house service generator. The elevation of the top of the top cover plate shall be 209.0 feet on each generator. The approximate elevation of the turbine bearing will be:

For the main units_____

For the house service units_____

For the information of the generator contractor, the turbine contractor will be required to furnish the necessary guide bearing at the approximate center of the long shaft on the house service unit.

The generator contractor shall cooperate with the turbine contractor in determining the size of shaft necessary for stability and shall furnish the size and type of shaft required for the generator to operate satisfactorily with the turbine without any additional cost to the Government over that covered by the contract price. The turbine contractor is required to furnish all coupling bolts and guards for the couplings between the generator and turbine shafts. To insure accurate alignment of the turbine and generator shafts, the generator shafts with thrust collars mounted thereon shall be shipped and loaned to the turbine contractor, who shall ream the coupling bolt holes, test shaft sections individually and then assemble the entire shaft on trunnions or vertically for alignment check, to be witnessed and approved in writing jointly by the generator contractor, the turbine contractor, and the contracting officer. The generator and turbine contractors will be required to cooperate as to the time of such tests in such a manner as to cause as little delay as possible in either shipping schedule and any additional costs resulting to either contractor from any delay or faulty wormanship by the other con-

tractor shall be adjusted between the contractors concerned without any additional cost to the Government. Shipment of shafts for this test will be made on Government bill of lading, at Government expense. The generator contractor shall load the shafts f.ob.b. cars at his plant for shipment to the turbine contractor. After the tests are completed the turbine contractor will load the generator shafts and include them in the shipment of turbine parts to the St. Lawrence plant. Tolerances for the shafts, bearing surfaces and coupling flanges shall be as follows:

Individual Turbine and Generator Shafts.

All cylindrical bearing portions of shafts shall show not more than .0015 inch on the indicator, or .00075 inch from straight. Faces of coupling flanges .001 inch and thrust bearing faces shall show a maximum of .0015 inch on the indicator.

The female portion of the generator shaft shall show a runout of not more than .001 inch on the indicator.

Combined Turbine and Generator Shafts.

All cylindrical bearing portions of the shaft, including guide bearing surfaces, shall show not more than .003 inch on the indicator, or .0015 inch from straight. Thrust bearing faces shall show not more than .0015 inch on the indicator.

At the option of the generator contractor and the turbine contractor, with approval of the contracting officer, the turbine shafts may be shipped to the generator contractor for the reaming of coupling bolt holes and alignment check as specified, shipment to be made on Government bill of lading at Government expense, but loading and unloading to be done at the expense of the contractors as indicated above in this paragraph.

The generator contractor shall exchange with the turbine contractor, and the governor contractor, all necessary drawings, dimensions, templates, gages, and other information required to insure the complete and proper design and manufacture of all connecting or related parts of the generators, turbines and governors. No extra compensation shall be claimed because of any modifications required to accomodate equipment of another contractor, except as is otherwise specifically provided herein. All adjustments shall be made between the respective contractors without involving extra cost to the Government. Four copies of all drawings and all correspondence relating to drawings and specifications interchanged between contractors shall be sent to the contracting officer.

Each generator shaft shall be accurately machined and finished throughout and polished at the bearing surfaces and shall be bored axially with a hole not less than six inches in diameter for the main generators and not less than four inches in diameter for the house service generator, finished sufficiently smooth to permit visible inspection of the interior structure of the shaft.

The coupling flanges shall be of male and female constructions with the female portion on the generator shaft and the generator and turbine contractors shall cooperate to secure an accurate sliding fit between the two flanges. The generator contractor shall furnish the required template to the turbine contractor.

2-14. BEARINGS. Each generator shall be provided with a non-spherical, adjustable shoe, Kingsbury type, thrust bearing, located below the rotor. This bearing shall have ample capacity to support the combined weight of the rotating parts of the generator, the exciters and the turbine, including the

hydraulic thrust of the turbine runner. The value of the turbine load is given in paragraph 2-06. The bearing area shall be such that the bearing pressure shall not exceed approximately 400 pounds per square inch of active bearing surface. The bearing shall be capable of operating continuously under this load at any speed from half rated speed to 110 per cent of rated speed, for at least one-half hour at runaway speed, and for at least one hour as low as 10 r.p.m. with normal flow of water in the oil cooler. Starting at normal temperature, the bearing shall be capable of operating at normal speed without cooling water for at least fifteen minutes.

A cooler with suitable coils of corrosion-resisting metal shall be provided and shall have sufficient capacity to maintain the oil at the proper temperature with water temperature of 20 degrees Centigrade and a minimum pressure of twenty (20) pounds per square inch. It shall be designed to withstand a water pressure of seventy-five (75) pounds per square inch. A sight flow indicator with an alarm contact shall be included for the water supply line. The contractor shall furnish companion flanges on the intake and outlet pipes.

The generator contractor shall furnish an electrically operated valve, with contacts for indicating lights, to be mounted in the water line supplying the bearing oil coolers. This valve will be controlled from the switchboard and shall be of a type that is not continuously energized in either the open or closed position. Control will be by 125 volt D.C. The contractor shall furnish and install all water piping from the bearing to a point near the outer end of the bearing bracket and shall properly protect this against sweating. All other water pipes and fittings will be furnished and installed by others. Should the coolers be external of the bearing reservoir, this contractor shall furnish all required electrically driven pumps and piping required for this circulation system.

Each generator shall be provided with one guide bearing below the rotor. This guide bearing shall be capable of withstanding all stresses incident to the operation of the unit at any speed up to the maximum runaway speed of the turbine. It shall be of the self-lubricated, babbitt-linned adjustable shoe type. Proper packing gland shall be provided above the oil reservoir and a pipe connection shall be made to the labyrinth seal to permit connection to the draft tube to create a vacuum in the labyrinth and so prevent the escape of oil or oil vapor into the generator. This pipe shall be supplied and installed to a point near the outer edge of the bearing bracket and left for connections by others. The guide bearing shall be so designed that it can be dismantled without disturbing the thrust bearing or the generator rotor. The thrust bearing shall be arranged to permit adjustment, dismantling and assembly without disturbing the rotor or stator other than by jacking the load from the bearing. Sufficient oil shall be supplied for the initial filling of all oil reservoirs.

If a second guide bearing, above the rotor, is furnished, it shall be of the same general type as the lower guide bearing and shall have similar protection against oil leakage, similar temperature detectors and relays, and similar dismantling provisions. Any upper guide bearing shall be between the generator rotor and the exciter.

One standard 10 ohm, embedded temperature detector shall be provided in each shoe of the thrust bearing, and two in each guide bearing, located to indicate the hottest spots. The contractor shall provide suitable leads, in conduit, from these detectors and a suitable terminal board mounted on the bearing bracket or stator frame in a location approved by the contracting officer.

In proximity of the babbitt of each thrust and guide bearing shall be installed the bulb of a pneumatic type bearing temperature relay of approved make which will close a pair of contacts when the bearing temperature reaches approximately 105 degrees Centigrade. These relays shall be mounted in an approved location and leads brought to the above-mentioned terminal board. The contacts shall have a continuous current carrying capacity sufficient for all connected equipment and shall be suitable for 125 volt D.C. operation.

The bearing bracket shall be of sufficient strength and rigidity to support, without undue vibration, the weight of the entire rotating element of the generator and turbine with the hydraulic thrust thereon. The bearing bracket shall be so constructed that it can be removed through the generator stator without disturbing the same. The pit beneath the generator will be approximately 28 feet in diameter for the main units and approximately 12 feet in diameter for the house service unit, and the generator stator shall be designed to allow at least equal openings for the passage of turbine parts.

2-15. HOUSING, STAIRS, RAILING, ETC. Every effort shall be made to design and build these generators so as to present a pleasing appearance and the contractor shall cooperate with the contracting officer to this effect. Drawing No. 48-E-7 attached hereto shows the desired arrangement of housing, etc., and the contractor shall maintain this general scheme, so far as is practicable, varying the details to suit his particular generator design, but subject to approval by the contracting officer. Should there be more than one generator contractor, they will be required to cooperate to the end that the external appearance of the generators will be as uniform as practicable.

Stairs, railings and platforms outside of the generator housing will be furnished by others but the generator contractor shall cooperate in the arrangement for supporting the same wherever they are to be attached to any part of the equipment furnished under this contract.

Any inspection doorways or handholes made in the generator housing shall be closed with approved doors or covers, and made air tight with satisfactory packing and anti-rattle latches or similar fastenings.

The generator housing and stator shall be concentric.

2-16. BREAKS AND JACKS. Each generator shall be provided with suitable air-operated brakes of sufficient capacity to bring the rotating parts of the generator and turbine to a stop from one-half normal operating speed within 7-1/2 minutes after the brakes are applied, without injurious heating of the braking surface on the generator rotor, without field excitation on the generator, and with leakage through the turbine gates not exceeding an amount which will produce one per cent (1%) of the full rated generator torque. The piping system to the brake cylinders shall be constructed so as to equalize the pressure at all cylinders and operate all brake shoes simultaneously. Control equipment for automatic and manual admission to and release of air from the operating cylinders of the brakes will be supplied by the governor contractor. The air brakes shall be designed for operation with an air pressure of one hundred (100) pounds per square inch. The brakes shall also be designed to serve as hydraulic jacks to lift the generator and turbine rotor for removal or adjustment of the thrust bearings. This lift shall not exceed 5/8 inch for the main units and 3/8 inch for the house ser-

vice unit and all parts of the generator shall be so constructed as to permit this lift without dismantling or disconnecting any parts. A portable high pressure oil pump, Watson-Stillman or equal, for use with hydraulic lifting jacks shall be furnished by this contractor and an approved provision shall be made for blocking the rotor in the fully raised position. All piping used in connection with the air brakes and hydraulic lifting jacks shall be furnished complete to a point below the bearing bracket and shall be capable of withstanding the maximum oil pressure required to lift the rotor. The brake shoes shall be provided with suitable moulded asbestos friction wearing surfaces which shall be renewable.

2-17. EXCITERS. Each main generator shall be provided with a direct-connected, shunt wound, 250 volts, separately excited main exciter mounted above the generator, and a direct-connected, compound wound, 250 volts, self-excited pilot exciter mounted above the main exciter. The house service unit shall be provided with a direct-connected self-excited main exciter, mounted above the generator. The method of mounting the exciters shall be such that either the armature or the field of either exciter can be readily removed and replaced by a spare part. The capacity of the main exciter shall be adequate to supply the field excitation current of the generator to which it is connected when the latter is continuously operated at normal rated kw output, rated power factor lagging, and 105% of normal rated voltage. The capacity of the pilot exciter shall be adequate to supply the field excitation current of the main exciter to which it is connected with the above load conditions on the alternator. The temperature rise of the main and pilot exciters when delivering rated output continuously shall not exceed forty degrees (40°) Centigrade for the armature and field winding, and fifty-five degrees (55°) Centigrade for the commutator. The armature and the field windings of both main and pilot exciters shall be insulated with Class A insulation as defined by the A.S.A. Standards. The main exciter shall be designed to have a speed of response as defined and measured in accordance with the latest recommendations of the A.I.E.E. of not less than 0.5. On the main units the main exciter shall be designed for operating with the armature leads connected directly to the field collector rings and in connection with an automatic voltage regulator. On the house service unit, one main exciter lead shall be brought out to a single pole field circuit breaker. The main and pilot exciters shall be designed to operate safely at the runaway speed specified for the main generator. Commutation shall be practically sparkless from no load to one hundred fifty percent (150%) ofthe full load current as defined by the A.I.E.E. Standards.

2-18. VOLTAGE REGULATORS. An automatic voltage regulator of the latest improved high speed type, responsive to average three-phase voltage, complete with all necessary relays, cross-current compensators, transfer switches, current and potential transformers and auxiliary appurtenances, designed for use with high speed response excitation, shall be furnished with each generator. The voltage regulator, together with the generator excitation system shall be capable of responding to changes in the alternating current voltage in a period of three cycles. It shall function without hunting and shall prevent dangerous rise in main and pilot exciter voltage at runaway speeds. The contractor shall furnish all transfer switches, control switches, indicating lights, hand operated voltage adjusting rheostat, flush mounting main control element and all other required regulator parts

that mount on the main switchboards, and wiring diagrams and dimension drawings for the same. The main generators shall be provided with all voltage regulator apparatus required for satisfactory operation of the generators in parallel. All relays, control switches, etc. required for the regulators but not mounted on the main switchboards shall be mounted by this contractor on the face of the main exciter rheostat or on a steel panel adjacent thereto. This panel shall match in appearance as nearly as practicable with the face of the rheostat. For each main unit a main exciter rheostat with field discharge resistor shall be furnished with the regulator and shall be arranged for remote operation from the main switchboard by the regulator and by a manually operated switch. Provision shall be made for adjustment to allow for any variation between calculated and test values of field saturation curve.

For each main generator a remote controlled main exciter field breaker, a hand-operated pilot exciter field rheostat, and a pilot exciter voltmeter shall be furnished and mounted on the above-mentioned steel panel. A similar remote controlled field breaker, hand-operated exciter rheostat and an exciter volmeter shall be furnished and mounted for the exciter on the house service generator. Terminal blocks shall be provided for all wiring external to these panels and complete wiring diagrams shall be furnished.

2-19. PERMANENT MAGNET GENERATOR AND TACHOMETER. The governor contractor will furnish a permanent magnet generator, properly insulated from other equipment, for driving the governor, and approved overspeed switch, means of indicating turbine breakaway and final stopping of the unit, and a tachometer for each generator. The generator contractor shall cooperate to provide proper mounting for these parts and wiring, in concealed conduits, for the same, brought to approved terminal blocks in the base of the stator at an agreed location.

2-20. SHOP INSPECTION AND TESTS. All materials and workmanship shall be subject to inspection by the contracting officer at the place of, and at all times during, manufacture.

The contractor shall notify the contracting officer as far in advance as practicable when each machine will be ready for test so that the test may be witnessed by his representative.

All main exciters and pilot exciters shall be subjected to the following tests at the factory:

a. Dielectric test after complete assembly.
b. Measurement of resistance of the armature and field windings.

The exciter for the house service generator, one main exciter for the main generator and one pilot exciter shall be subjected to the following tests at the factory: (Should there be more than one manufacturer for the eighteen main generators, this shall be interpreted to mean one main exciter and one pilot exciter of each manufacture.)

c. Heat run to determine the temperature rise under continuous operation at rated full load.
d. Test to determine the saturation and regulation curves.
e. Tests to determine the losses and efficiency
f. Test of overload commutation.
g. Test to determine speed of response.

The tests on the exciters shall be conducted in accordance with the current A.S.A. Standards and the results of the tests shall determine whether or not the contractor's guarantee and the requirements of these specifications have been fulfilled. Two certified copies of the results of the tests shall be furnished to the contracting officer, and one copy shall be furnished to the Division Engineer. The contractor shall also furnish, in like manner, copies of curves showing the characteristics of the exciters as determined by the factory test, as follows:

Efficiency, plotted against amperes output.
Armature copper loss, plotted against amperes output.
Field copper loss, plotted against amperes output.
Core and stray losses, plotted against amperes output.
Total losses, plotted against amperes output.
Saturation open circuit volts, plotted against field amperes.
Regulation, volts plotted against amperes output.
Calculated voltage rise at runaway speed.

For the main generators, complete assembly of the generators at the factory will not be required. The insulation between turns of the stator coils shall be tested at the factory by impressing an alternating potential at suitable frequency across each coil so as to produce a voltage of ten (10) times normal operating voltage between adjacent turns. The insulation between turns of the field coils of the generator shall be similarly tested so as to produce a voltage of forty (40) volts between adjacent turns.

The house service generator shall be completely assembled at the factory and subjected to all shop and field tests specified for the main generators. After erection in the field this generator and its exciter shall again be subjected to the standard high potential tests.

All shafts shall be tested as specified in paragraph 2-13.

All oil coolers shall be subjected to a static water pressure of 75 lbs. per square inch for a period of one hour and shall show no leak.

The waiver of any test, or of the witnessing thereof by the contracting officer, shall not constitute relinquishment of the contractor's responsibility to fully meet the requirements which were to have been demonstrated by the test.

2-21. FIELD ERECTION. The contractor shall furnish all labor, tools, equipment, and materials and be responsible:

For furnishing proper foundation bolts and drawings in sufficient detail to permit others to set the bolts.

For setting and grouting all sole plates for the stator and bearing brackets.

For complete erection of all generator parts including the exciters and housing and placing of the air coolers. The rheostats, regulators, and any other auxiliaries furnished by the contractor, but mounted remote from the units by others shall be unloaded and stored by the contractor until such time as they can be received by the electrical contractor or the general building contractor who is to install them.

For placing of bolts in, and the shield on, the coupling between generator and turbine.

For alignment of the generator with reference to the turbine.

For dynamic balance of the generator rotor and all adjustments required for the same so that the generator will operate under any load con-

ditions without detrimental vibrations or objectionable noises.

For cleaning up in accordance with the requirements of paragraph 1-37.

2-22. FIELD TESTS. After the main generators and auxiliary equipment have been installed in the power plant ready for operation, the generators shall be tested by and at the expense of the generator contractor to determine whether or not the contractor's guarantees, and the requirements of these specifications, have been fulfilled. The test shall be made in accordance with the applicable standards of the American Institute of Electrical Engineers in effect at the time of opening of bids, except as herein noted. Each generator shall be subjected to the following tests:

a. Dielectric test of armature and field windings. For this test the Government will furnish the required transformer, breaker, rheostat, and voltmeter.
b. Resistance of armature and field windings.
c. No-load saturation test.
d. Short-circuit saturation test.
e. Determination of core losses.
f. Test to show time required for the rheostat to make full travel. Each pilot exciter rheostat or resistor shall be tested to determine the sufficiency of the field-reducing resistance to keep the voltage of the pilot exciter within safe limits when the unit is operating at runaway speed.
g. In addition to the above listed tests, the contractor shall perform without extra charge, any minor tests required to establish conformance of the equipment with the guarantees and the specifications.

One generator of each manufacturer shall be subjected to the following tests:

h. Telephone interference factor determination.
i. Short-circuit test to demonstrate that the generator is capable of withstanding short-circuit stresses without injury when the machine is operating under rated load. This test shall be made by abruptly short-circuiting the generator when operating at no load, rated frequency and 10 per cent above rated voltage for a period of not more than 30 seconds. One of the current waves, when taken on an oscillograph, shall be practically completely offset. If the first short-circuit does not produce this, additional short-circuits shall be applied until such is obtained.
j. Determination of friction and windage.
k. Heat run to determine the temperature rise of the various parts of the generator when operating continuously at full rated output. Load will be provided at the expense of the Government.
l. Test to determine direct axis transient reactance.
m. Test to determine negative sequence reactance.
n. Test to determine zero sequence reactance.
o. Deviation factor of wave form: Oscillograms shall be taken of the wave form of the voltage of each phase of the armature winding when the generator is operating at normal rated voltage at no load.

p. Determination of time for brakes to stop the machine from one-half speed with driving torque reduced to 1% of rating and with main exciter field open.

q. Test to determine the short-circuit ratio.

The contractor shall keep the contracting officer advised as to time when field tests will be conducted and ample notice shall be given so that the contracting officer or his representative may arrange to witness the tests. Four certified copies of the results of the field tests and two copies of curves showing characteristics of the machines as determined by these tests shall be furnished to the contracting officer, and one copy of the results of the tests and one copy of the curves shall be forwarded to_____. The waiver by the contracting officer of any test, or of the witnessing of the same, shall not constitute relinquishment of the contractor's responsibility to fully meet the requirements which were to have been demonstrated by that test.

2-23. OVERSPEED TEST. Each main generator shall be operated, within one month after it has been installed, at runaway speeds specified in paragraph 2-06 for a period of not more than 5 minutes after the full speed has been attained. This test is to demonstrate that the thrust bearing will not overheat and that all parts of the generator will successfully withstand stresses incident to runaway speed.

2-24. PATTERNS AND TEMPLATES. All parts shall be made accurately to standard gages where possible so as to facilitate replacement and repair. The contractor shall provide and retain in storage for at least ten years, free of cost to the Government, sufficient templates, gages, patterns or records, to allow the contractor to make repair or replacement of parts. Any special templates and gages required for erection shall be furnished and shall become the property of the Government.

2-25. TOOLS AND SPECIAL EQUIPMENT. The generator contractor shall furnish for each size of unit a complete set of end wrenches and any special wrenches, tools or equipment that may be necessary or convenient for assembling or dismantling any part of the generators and auxiliary equipment. He shall also furnish a satisfactory lifting device for attaching the heavier parts to the crane lifting beam or beams and proper eye bolts, hooks, slings, etc. for lifting all other parts. In designing such lifting devices the contractor shall cooperate with the crane manufacturer and such other generator manufacturers as may be building one or more of the generators to the end that all lifting devices shall successfully operate with one set of lifting beams furnished by the crane manufacturer. He shall submit with his proposal a complete detailed description and itemized list of the tools and equipment which he proposes to furnish and all such tools and equipment shall become and remain the property of the Government. The smaller tools shall be mounted on a neat sheet steel board provided with means for ready identification of tools.

2-26. SPARE PARTS. The following spare parts shall be included by the contractor for each group of six main generators and by the contractor for the house service generator:

One complete set of wearing parts for thrust bearing, including rotating member and complete set of babbitted stationary members.

One complete babbitted liner for the guide bearing or bearings.

One complete throw or belt of main generator coils and the necessary materials for installing the same.

Two complete field coils of each type used, including necessary insulation for installation.

One complete field coil of each type for each type of exciter, including necessary insulation for installation.

Two brush holder stud assemblies, complete with insulation and brush holders, of each type furnished under this contract.

One complete set of contracts, springs and coils as required for each type of relay, contractor, transfer and auxiliary switch and control element furnished under this contract.

One complete set of gaskets and packing.

Two complete sets of all brushes for exciters and main field.

All spare parts furnished shall be interchangeable with and shall be of the same material and workmanship as the corresponding original parts.

2-27. LATENT DEFECTS, ERRORS AND OMISSIONS. Any apparatus or part thereof which, within one year from date the apparatus is placed in operation, shows defects not disclosed prior to acceptance by the Government shall be promptly replaced by the contractor, free of all costs to the Government and all expense of transportation and installation of such replacement or replacements shall be borne by the contractor. Deductions may be made from any payments due the contractor for any expense incurred by the Government in correcting errors or omissions on the part of the contractor.

2-28. RIGHT TO OPERATE UNSATISFACTORY APPARATUS. The Government shall have the right to operate any and all apparatus as soon as, and as long as, it is in operating condition whether or not such apparatus has been accepted as complete and satisfactory, except that this shall not be construed to permit operation of any apparatus which may be materially damaged by such operation before the required alterations or repairs have been made. All repairs or alterations required of the contractor shall be made at such time as the Government may be able to operate satisfactorily without the apparatus.

2-29. PAINTING. All unfinished surfaces of all apparatus, except those surfaces which will be embedded in concrete, shall be thoroughly cleaned, filled and painted by the contractor at the factory, with a suitable priming paint satisfactory to the contracting officer. Final painting of the apparatus will be done by others after erection is completed. All finished surfaces shall be protected from corrosion by a readily removable rust preventative compound. All finished brass work shall be suitably wrapped or otherwise protected from damage during shipment and installation.

2-30. METHOD OF SHIPMENT. The contractor shall load all materials and Apparatus for shipment in such a manner and in such type of cars as will permit the use of the power house crane for unloading parts requiring this and shall be held responsible for and shall promptly replace all materials and apparatus lost or damaged because of improper packing or loading.

Invitation No. _____

STANDARD GOVERNMENT FORM OF BID
(Construction Contract)

(Place)_____

(Date)_____

To: The District Engineer
St. Lawrence River District
U. S. Engineer Office
Massena, New York

In compliance with your invitation for bids dated _____ _____, and subject to all the conditions thereof, the undersigned _____ a corporation organized and existing under the laws of the State of _____, a partnership consisting of _____ _____ _____ or an individual trading as _____ of the city of _____, hereby proposes to furnish all plant, labor and materials, and perform all work specified in the following schedules, in strict accordance with the specifications, schedules, and drawings, for the consideration of the following prices:

The contractor shall furnish all labor, materials, plant and equipment to perform all the work necessary to complete the manufacture of generators and appurtenances, deliver the same f. o. b. railroad cars at points designated in his bid, unload the same from the cars and erect them in the Barnhart Island power house, all in accordance with the attached specifications for the consideration of the unit prices as follows:

Schedule	Unit	Description	Quantity	Amount
I	Lump Sum	55,000 kva generators and appurtenances	6	
		Floor plates for support of rotors as specified in paragraph 1-31	2	_____
II	Lump Sum	55,000 kva generators and appurtenances	6	_____
III	Lump Sum	55,000 kva generators and appurtenances	6	_____
IV	Lump Sum	7,500 kva generators and appurtenances	1	_____

Bidder may bid on any one schedule or combination of schedules. The contracting officer reserves the right to change generator unit numbers in any or all schedules to insure contract for all units in the United States portion of the power house.

Each bidder shall submit with his proposal, the following, data to accompany his bid on Schedule I, II or III for 55,000 kva generators:

Drawings, photographs, or cuts:

a. Of generators of type proposed.
b. Showing proposed rotor construction.
c. Of proposed bearings.

Description of proposed regulators.
Quantity of cooling air required to be circulated per minute.
General dimensions and weights of stator parts as shipped and as assembled.
General dimensions and weights of rotor parts as shipped and as assembled.
Proposed arrangement and size of sole plates for the stator and for the bearing bracket and weight on each during operation.
General dimensions of bearing bracket.
Overall height of assembled unit above top cover plate.
Overall diameter of generator housing.
Distance from top cover plate to stator sole plates and to bearing bracket sole plates.
List of tools and special equipment to be furnished with generator in accordance with paragraph 1- of Detail Specifications.
Sizes of inlet and outlet pipes and amount of water required for air coolers.

Each bidder shall submit with his proposal the following data to accompany bid Schedule IV for one 7,5000 kva generator:

Drawings, photographs, or cuts:

a. Of generators of type proposed
b. Showing proposed rotor construction.
c. Of proposed bearings.

Description of proposed regulators.
Quantity of cooling air required to be circulated per minute.
General dimensions and weights of stator parts as shipped and as assembled.
General dimensions and weights of rotor parts as shipped and as assembled.

Proposed arrangement and size of sole plates for the stator and the bearing bracket and weight on each during operation.

General dimensions of bearing bracket.

Overall height of assembled unit above top cover plate.

Overall diameter of generator housing.

Distance from top cover plate to stator sole plates and to bearing bracket sole plates.

List of tools and special equipment to be furnished with generator in accordance with paragraph of Detail Specifications.

Sizes of inlet and outlet pipes and amount of water required for air coolers.

It is hereby warranted that in the event award is made to the undersigned there will be used in the performance of the work covered by the contract only such unmanufactured articles, materials, and supplies as have been mined or produced in the United States, and only such manufactured articles, materials and supplies as have been manufactured in the United States all from articles, materials, or supplies mined, produced or manufactured, as the case may be, in the United States except as noted below or otherwise indicated in this bid or authorized in the specifications.

The undersigned agrees, upon receipt of written notice of the acceptance of this bid within 60 days after the date of opening of the bids, to execute the standard form of Government contract (revised September 9, 1935,) in accordance with the bid as accepted, and give performance and payment bonds with good and sufficient surety or sureties for the faithful performance of the contract, and for the protection of all persons supplying labor and materials in the prosecution of the work, within 10 days after the prescribed forms are presented for signature.

Performance will begin within 30 calendar days after receipt of the notice to proceed and will be completed as specified in Table I of the specifications.

The data sheets attached hereto will be made a part of the contract. All blank spaces will be filled in by the contractor, and no changes in the sheets as filled in will be allowed after award of contract except upon specific written orders of the contracting officer. One manufacturer only will be specified for each item.

_____
(Full Name of Bidder)

_____
(Witness to Signature)

By _____

(Corporate Seal)

_____
(Business Address)

Note: Read Standard Government Instructions to Bidders before preparing this bid.

DATA SHEET - SCHEDULES I, II & III

Guaranteed Characteristics:

55,000 KVA Alternating Current Generator

Regulation, in per cent of rated voltage, not more than _____

Unsaturated, direct-axis, transient reactance not more than _____

Efficiency at 90% power factor at twenty-five per cent (25%) of rated kva, not less than _____

At fifty per cent (50%) of rated kva, not less than _____

At seventy-five per cent (75%) of rated kva, not less than _____

At one hundred per cent (100%) of rated kva, not less than _____

Exciters	Main	Pilot
Rating in amps at 250 volts	_____	_____
Efficiency:		
At fifty per cent (50%) of rated capacity	_____	_____
At seventy-five per cent (75%) of rated capacity	_____	_____
At one hundred per cent (100%) of rated capacity	_____	_____

* * * * * * * * *

Shipping point (or points): _____

_____

_____

Guaranteed Maximum Shipping Weight (If more than one shipping point, give shipping weight from each point):

_____

_____

_____

_____

(Bidder)

By_____

DATA SHEET - SCHEDULE IV

Guaranteed Characteristics:

7,500 KVA Alternating Current Generator

Regulation, in per cent of rated voltage, not more than _____

Unsaturated, direct-axis, transient reactance not more than _____

Efficiency at 90% power factor at twenty-five per cent (25%) of rated kva, not less than _____

At fifty per cent (50%) of rated kva, not less than _____

At seventy-five per cent (75%) of rated kva, not less than _____

At one hundred per cent (100%) of rated kva, not less than _____

Exciters	Main	
Rating in amps at 250 volts	_____	_____
Efficiency:		
At fifty per cent(50%) of rated capacity	_____	_____
At seventy-five per cent (75%) of rated capacity	_____	_____
At one hundred per cent (100%) of rated capacity	_____	_____

* * * * * * * * * *

Shipping point (or points): _____

_____

_____

Guaranteed Maximum Shipping Weight (If more than one shipping point, give shipping weight from each point):

_____

_____

_____

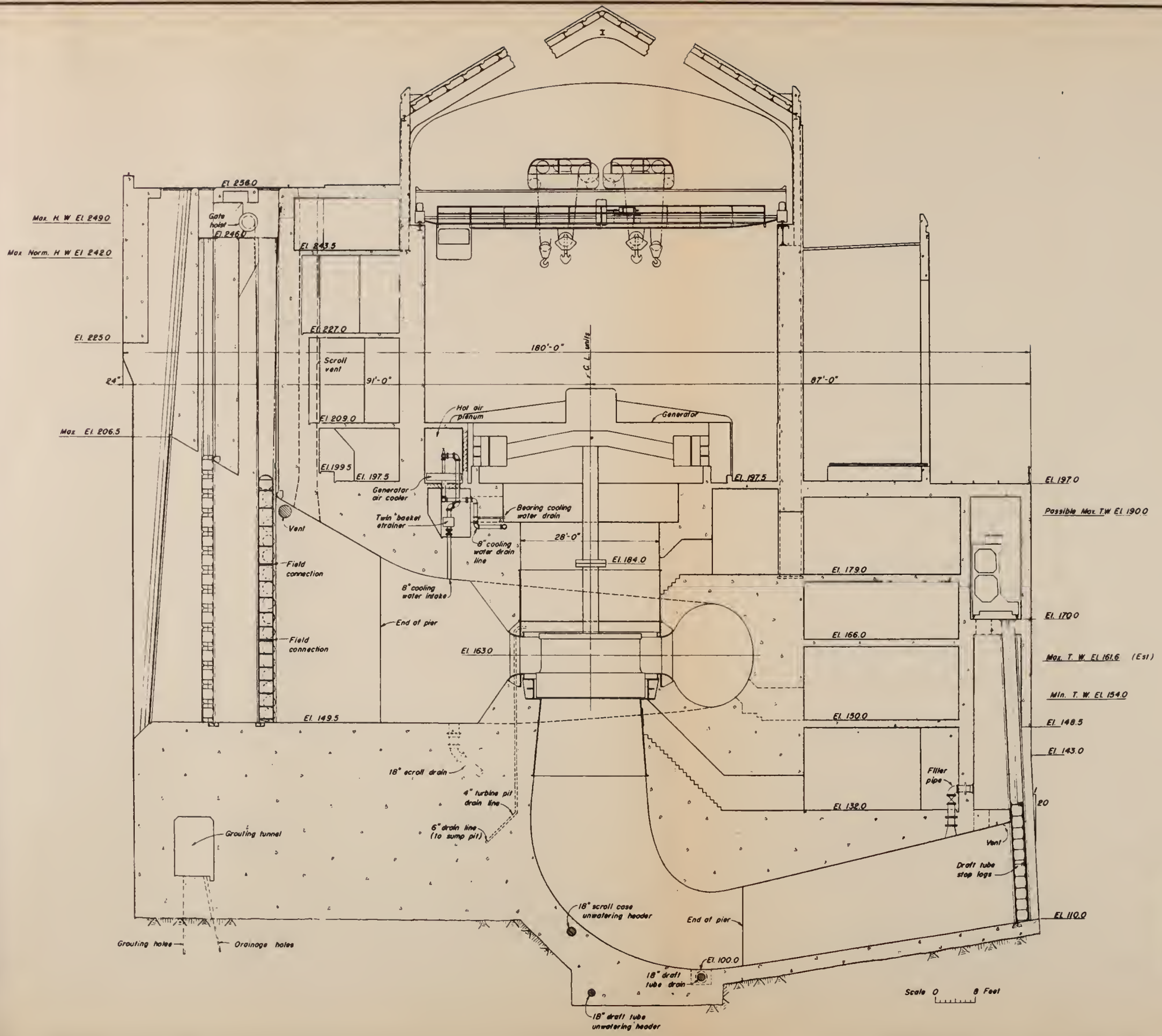
_____

(Bidder)

By_____

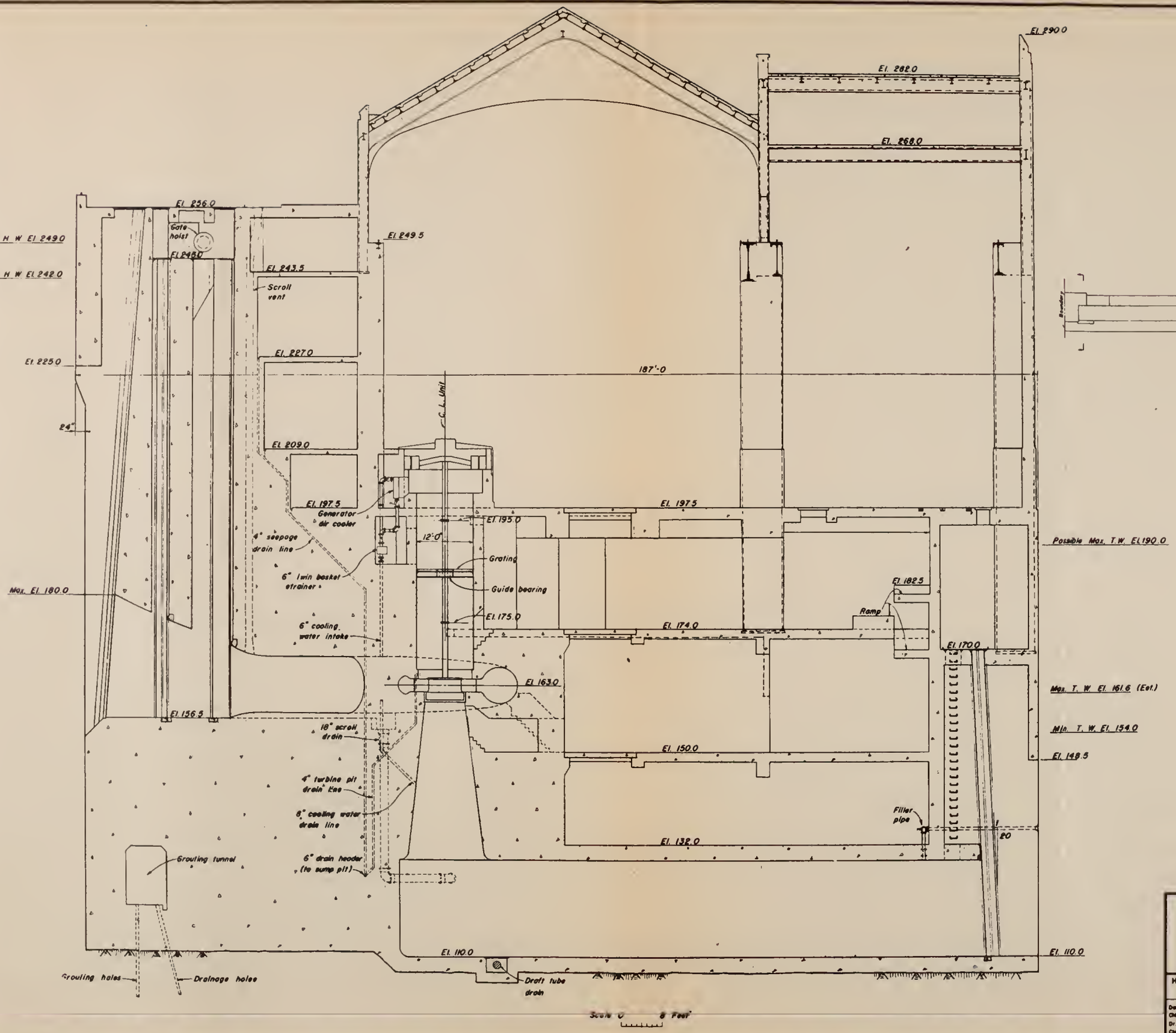
WAR DEPARTMENT

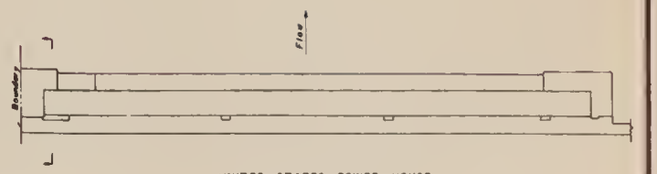
CORPS OF ENGINEERS, U.S. ARMY



ST. LAWRENCE RIVER PROJECT
BARNHART ISLAND POWER DEVELOPMENT
POWER HOUSE
TRANSVERSE SECTION THRU MAIN UNIT

HARZA ENGINEERING COMPANY ENGINEERS CHICAGO, ILLINOIS	U.S. ENGINEER OFFICE ST. LAWRENCE RIVER DISTRICT MASSENA, NEW YORK
Des. JF. Submit'd ____ Recom. ____ Approved ____ Chkd. JF Dr. ____ Chkd. ____	Recommended ____ Head Engineer Approved ____ Lt Col Corps of Engineers District Engineer
FILE NO. 48C11	SHEET NO. ____ OF ____ SHEETS Transmitted with letter or endorsement dated ____ 194_





UNITED STATES POWER HOUSE

KEY PLAN

Scale 0 200 Feet

ST. LAWRENCE RIVER PROJECT
BARNHART ISLAND POWER DEVELOPMENT
POWER HOUSE
TRANSVERSE SECTION THRU HOUSE UNIT

HARZA ENGINEERING COMPANY ENGINEERS CHICAGO, ILLINOIS		U.S. ENGINEER OFFICE ST. LAWRENCE RIVER DISTRICT MASSENA, NEW YORK	
Des. S.	Submitted	Recommended	Asst. Engineer
Chkd.	Recom.	Approved	Lt. Col. Corps of Engineers District Engineer
Dr.	Approved		Transmitted with letter of endorsement dated 194
Chkd.			
FILE NO. 48C15		SHEET NO. OF SHEETS	

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY

Railing

Flow

1'-0"

El. 197.0

Transfer car track

Railroad track

Grinding room

El. 197.5

87'-0"

Transfer car track

6" drain line

Removable hatch cover

Cable shaft

El. 197.5

Erection floor

Temporary railroad track

Sanding room

178'-0"

187'-0"

C.L. unit

Down

Up

El. 197.5

Up

Down

2'-6"

8" cooling water supply line

8" cooling water drain line

Elevators

46'-6"

33'-6"

19'-0"

75'-0"

15'-0"

75'-0"

19'-0"

Floor drains

91'-0"

El. 197.5

6'-6"

Up

Drain trench

El. 199.5

Elevator

3" seepage drain line

Scroll vent

C.L. intake

7'-6"

17'-8"

6'-0"

17'-8"

6'-0"

17'-8"

7'-6"

80'-0"

203'-0"

24'

BLOCK 36

BLOCK C

Scale 0 8 Feet

B N-2 18 20 25 30 35 38 C

UNITED STATES POWER HOUSE

KEY PLAN

Scale 0 200 Feet

KEY SECTION

Scale 0 100 Feet

ST. LAWRENCE RIVER PROJECT

BARNHART ISLAND POWER DEVELOPMENT

POWER HOUSE

PLAN AT EL. 197.5 FLOOR BLOCKS 36 AND C U.S. POWER HOUSE

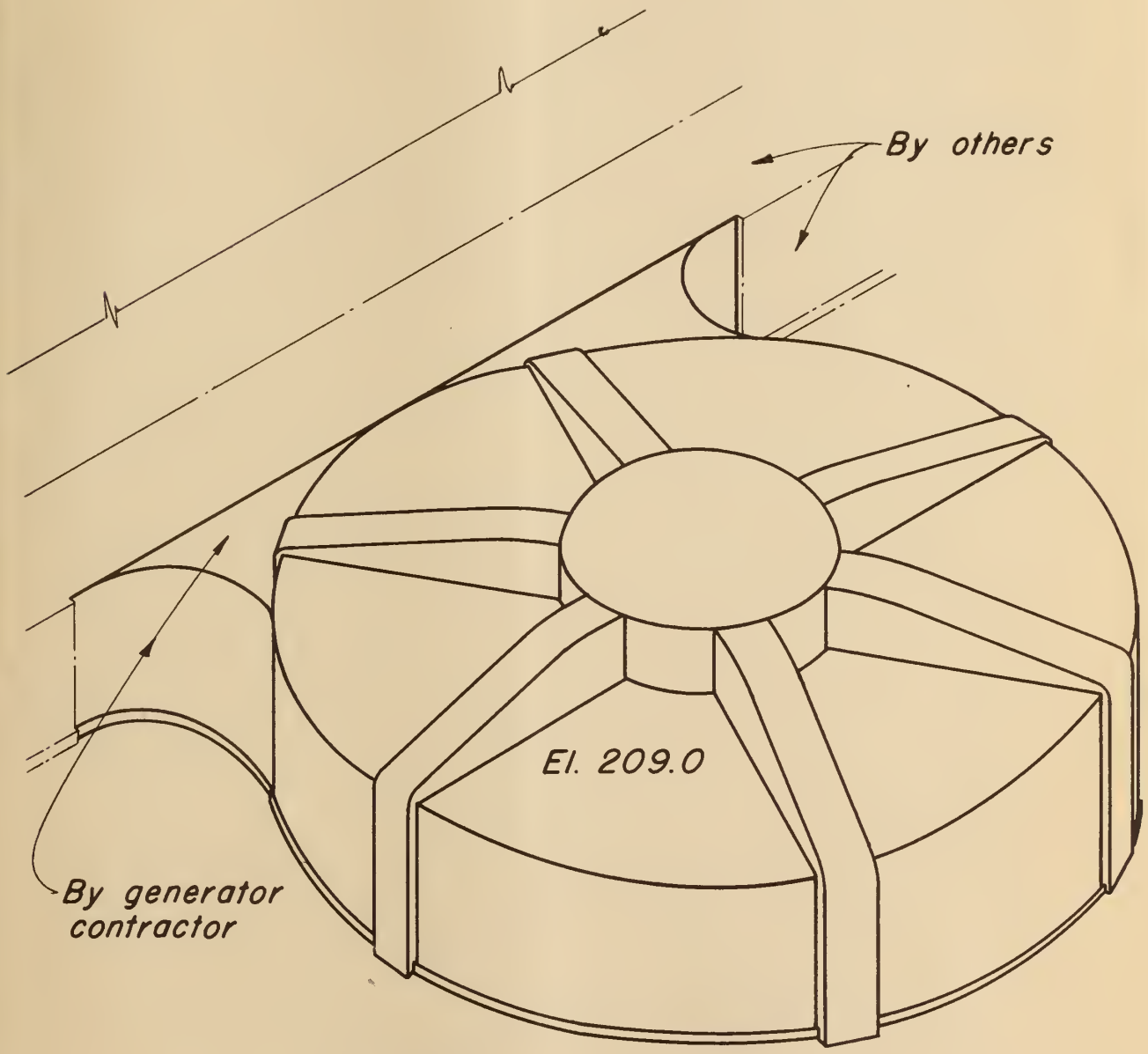
HARZA ENGINEERING COMPANY ENGINEERS CHICAGO, ILLINOIS	U.S. ENGINEER OFFICE ST. LAWRENCE RIVER DISTRICT MASSENA, NEW YORK
Dep. E. ____ Submitted ____	Recommended ____ Resd. Engineer
Chkd. ____ Recom. ____	Approved ____ Lt Col Corps of Engineers District Engineer
Dr. RETT Approved ____	
Chkd. BRL	
FILE NO. 48C56	SHEET NO. ____ OF ____ SHEETS (Transmitted with letter or endorsement dated ____ 194)

HARZA ENGINEERING COMPANY
CHICAGO
CHARLESTON S.C.

SUBJECT GENERATOR
PROPOSED HOUSING

COMPUTED _____ CHECKED _____

PROJECT ST. LAWRENCE
FILE NO. 48E7
DATE 12-28-41 PAGE _____ OF _____



El. 197.5

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Connecticut
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